Integrated Resource Inventory

INTEGRATED RESOURCE INVENTORY
OF DEEP BASIN STUDY AREA (NTS 83L)
VOLUME III

Alberta
ENERGY AND
NATURAL RESOURCES
Resource Evaluation
and Planning

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OF DEEP BASIN STUDY AREA (NTS 83L)
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VOLUME III

NATURAL RESOURCES OF THE STUDY AREA

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1. BEDROCK GEOLOGY

The study area is underlain by a succession of marine and non-marine sedimentary strata ranging in age from Triassic to Tertiary (Figure 154). The majority of these bedrock units are exposed across the map area in two very distinct geological environments. The first is referred to as the Rocky Mountain orogeny belt and consists of sedimentary rocks displayed in a series of homoclinal southwest dipping imbricate thrust sheets (Barnes, 1976). The second environment, which covers the majority of the study, is referred to as the Western Alberta Plains and Wapiti Plain. In this environment, Upper Cretceous to Lower Tertiary rocks form a broad northwest trending asymetric syncline (Allen and Rutherford, 1934).

Structural features within the foothills and mountains are much more pronounced than those associated with the plains. In the study, two structural groupings were recognized within the Rocky Mountain orogenic belt - the Front Ranges and the Foothills. Often these units are not easily defined or separable from each other, however, there are characteristic rock types and patterns of folding and faulting within each group.

The structure of the Front Ranges consists of a series of overthrust sheets lying between south-westerly dipping faults which have sliced the limestone formations into a number of blocks (Holland, 1976). Subsequent erosion of these complex blocks has produced the numerous parallel ranges which constitute the Front Ranges, with each range representing a major thurst sheet which has been displaced to the

northeast resulting in a steep northeast facing scarp (Alberta Wilderness Association, 1973). This general structure of large thrust sheets is much more evident south of the present study and is complicated by the presence of numerous smaller faults and folds formed prior and subsequent to the major faulting. This complexity of folding and faulting has produced numerous anticlines and synclines. Late Pleistocene cirque glaciation has accentuated the sharpness of the topography of the east and northeast facing scarps.

The boundary between the Foothills and the Front Ranges lies along a structural line which traces the easternmost major fault that thrusts Palaeozoic over Mesozoic formations. The eastern boundary of the Foothills is depicted through a series of southwesterly dipping "en echelon" thrust faults which separate strongly folded and faulted sedimentary formations from flat-lying or gently dipping formations to the east.

The intensity of structural deformation becomes less well defined near the margin of the foothills-plains (Holland, 1976). As a consequence it is possible to divide the foothills into the inner foothills, which are adjacent to the mountains, and the outer foothills which fringe the plains. The inner foothills are higher and more rugged than the outer foothills which have a more moderate relief and subdued topography. The inner subregion is composed of tightly folded Cretaceous rocks (Irish, 1965).

The Western Alberta and Wapiti Plains, which are located to the northeast of the foothills belt are underlain by a thick succession of

interbedded sandstone, siltstone, shales and mudstones of Late Cretaceousto Tertiary age. The regional structure of these strata is part of a shallow syncline referred to as the Alberta Syncline, the axis of which trends in a northwest direction. Strata on the northeast limb of the syncline dip to the southwest (less than 3 degrees) exposing successively older beds towards the northest. On the southwest limb, the strata dip to the northeast (5° to 15°) abutting against the complex folded and faulted Cretaceous beds marking the eastern margin of the foothills.

The bedrock strata can be divided into two units of simlar lithology. The older beds underlying the Wapiti Plains in the northeast consists of thinly bedded, non-marine, bentonitic sandstones and shales of the Wapiti Formation of Late Cretaceous age. This formation is overlain by Scollard Member of the Paskapoo Formation which is a marker between Wapiti equivalent and Paskapoo equivalent strata. It is largely characterized by its higher bentonitic content and thus relatively prone to failure.

The second bedrock unit is the younger Paskapoo Formation which consists of thicker calcareous sandstones interbedded with siltstone and shale of early Tertiary age (Barnes, 1976). This formation is thickest adjacent to the disturbed belt of the foothills where the Upper Cretaceous-Tertiary succession reverses dip (from southwest to 10 to 15 degrees northeast), thereby exposing the Cretaceous strata along a series of cuesta-like ridges that mark the edge of the folded belt.

2. QUATERNARY HISTORY

The Deep Basin area was covered by ice sheets during the Late Wisconsin period (20 000 to 7 000 BP), although some peaks such as Mount May (2 449 m) are thought to have extended above the ice sheets, and hence escaped this glaciation. Large erratics composed of quartzite, limestone and dolomite are found on the tops of many ridges up to 2 165 m (Irish, 1965). In addition, a large upland area of Tertiary gravels east of the Simonette River is thought to have escaped major glaciation. The landscape has since been modified by post-glacial erosion and deposition. This has resulted in a mantle of unconsolidated morainal materials covering much of the present-day Wapiti and Western Alberta Plains and the lower slopes of the Rocky Mountain Foothills and Rocky Mountains. Figure 155 illustrates the glacial and post glacial features of the study area. These include cirques, flutings, abandoned shorelines, eskers, glacial meltwater channels and dunes.

During the Late Wisconsin period, two major ice sheets were responsible for the sculpturing of the landscape; the Laurentide Ice Sheet which originated in the Keewatin District of the Northwest Territories and moved across the Interior Plains from the northeast. The Cordilleran Glacier Complex which originated to the west and southwest of the study area flowed northeast across the Western Cordilleran onto the Western Alberta Plain. The Laurentide ice is thought to have overridden Cordilleran ice in the area where the sheets met. The two ice sheets coalesced and flowed in a southeasterly direction along the eastern edge of the Rocky Mountain Foothills (Prest, 1976).

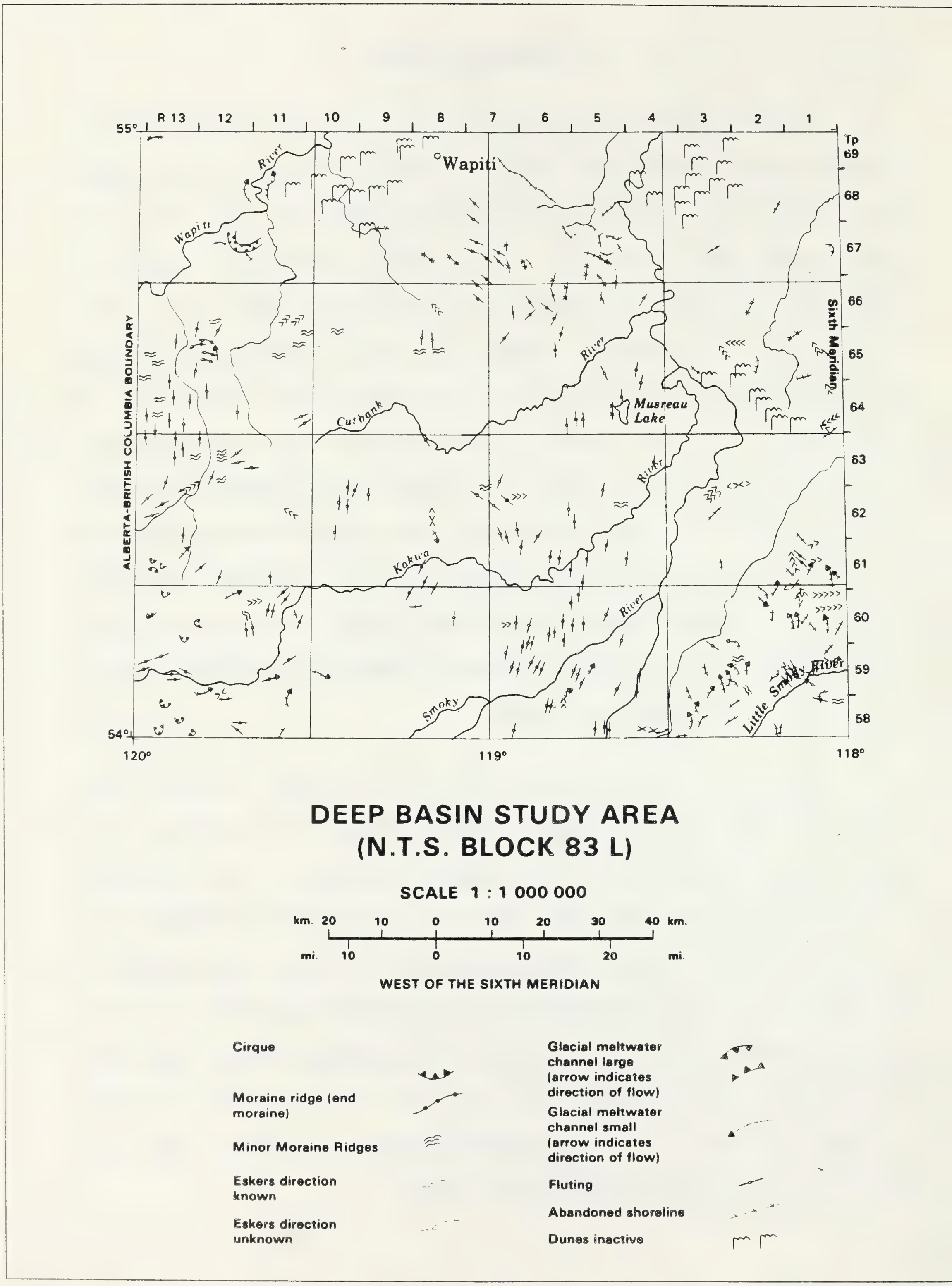

Figure 155: Glacial and Post Glacial Features

Erosion by the Cordilleran ice was limited to smoothing and rounding of existing peaks and ridges without effectively reducing relief. The erosiveness of the ice would have been much greater if the ice had been moving in a southwesterly direction against the scarps (Irish, 1965). Subsequent Late Pleistocene cirque glaciation further sculptured the landscape, especially on north and northeast exposures where jagged peaks, cirques and aretes predominate.

During the period of deglaciation the Laurentide ice retreated generally to the northeast, while Cordilleran ice dispersed largely by melting and stagnation of the ice masses as a whole (Nasmith, 1962). The number of advances and re-advances of both ice sheets in the area is hard to ascertain due to local ice front fluctuations during retreat stages, and active post-glacial erosion and deposition.

Major glaciofluvial terraces border the Smoky, Kakwa, Wapiti and Narraway Rivers and Sheep and Copton Creeks as a result of post-glacial erosion and deposition. These river valleys represented major outlets for glacial meltwaters during the retreat and stagnation of Cordilleran ice sheets.

Glacial Lake Peace-Bessborough (Mathews, 1976; St. Onge, 1972) was formed over most of the Wapiti Plains as the Laurentide ice sheet retreated to the northeast. The sediment load carried by glacial meltwaters from the retreating Cordilleran ice sheets resulted in the formation of numerous delta complexes within the lake. This, combined with slow but gradual retreat of lake levels from a maximum elevation of 850 m, has resulted in thin glaciofluvial materials overlying dark, heavy clays.

Large areas of glaciofluvial outwash materials were exposed following the recession of Glacial Lake Peace-Bessborough. Subsequent erosion and deposition by wind from the southwest, having a bearing of 8° north of east (Odynsky, 1958), has resulted in the formation of parabolic dunes across the Wapiti Plains. The two major source areas for these eolian deposits were the area in the vicinity of Nose Creek and the Wapiti River and the area between Big Mountain Creek and the Smoky River.

3. SOILS

Soil is an unconsolidated surficial material composed of mineral, air, water, and organic matter which is capable of supporting plant life. It is a dynamic system that develops at a particular place on the landscape, based on the varied interaction among parent materials, climate, topography and vegetation over time.

Within the Deep Basin study area the following soil orders were identified based on the Canadian System of Soil Classification (1978): luvisols, brunisols, organics, gleysols and regosols. Luvisols and brunisols account for most of the soils with organics, gleysols and regosols occurring locally throughout the study area. Previous soils research in the study area has included work by Lindsay, Wynnyh and Odynsky (1964) and by Twardy and Corns (1980).

The soil orders mentioned above reflect patterns of elevation, climate and drainage. The organic and gleysolic orders develop in response to the drainage factor while luvisols, brunisols and regosols show a zonation pattern with increasing elevation accompanied by increasing climatic severity.

Luvisolic soils develop at lower elevations within the study area, on glaciolacustrine and morainal materials. These soils are slightly acidic to moderately alkaline and have relatively high rates of nutrient cycling and cation exchange capabilities. The clay content of these soils is high, particularly on the glaciolacustrine materials, often resulting in very compact soil horizons. Subgroups present

include Orthic Gray Gleyed Gray, Solonetzic Gray, Gleyed Solonetzic Gray, and Brunsolic Gray Luvisols. The Solonetzic Gray and Gleyed Solonetzic Gray Luvisols are most common on glaciolacustrine deposits while the Brunisolic Gray Luvisols develop in coarser-textured materials, as well as at higher elevations where soil development is limited by climate.

The brunisolic soils generally occur at mid to upper elevations in the study area where climate and topography becomes a restricting factor to soil development. Colluvial and residual materials are usually associated with these soils at the upper elevations. Brunisols are also found at lower elevations, however, they are generally restricted to coarse-textured eolian and glaciofluvial materials. Subgroups include Eluviated, Eutric and Dystric Brunisols, Orthic Eutric and Dystric Brunisols and gleyed phases of all of these. In general, the orthic subgroups occur on very steep topography while the eluviated subgroups are more common on relatively gentle slopes. The Dystric Brunisols are more common in areas of continental till while the Eutric Brunisols occur in association with the less acidic cordilleran till.

Regosolic soils occur throughout the area on very steeply sloping colluvial slopes and in valley floodplains. In addition, they are also present at the highest elevations in the area where a combination of steep slopes and very severe climate restricts soil development.

Gleysolic and organic soils occur throughout the area in areas of poor drainage. As such they are generally found in lower slope positions or in depressional terrain.

This discussion of soils in the area is a generalized overview. More detailed information appears on the maps and in Volume I of this report.

4. CLIMATE

Climatic data are only available from a few stations in the Deep Basin study area (Appendix E) and thus climate cannot be analyzed in great detail. Several regional trends are apparent, however. Temperatures tend to decrease while precipitation increases with increasing elevation. These changes are reflected in the transition from deciduous to coniferous tree cover and from understories dominated by deciduous shrubs and broad-leaved herbs to ones dominated by ericaceous shrubs and mosses while passing through the Boreal Mixedwood - Boreal Foothills - Boreal Uplands - Subalpine sequence of ecoregions. Local variations in major river valleys and in the high relief topography of the foothills and mountains cause considerable deviation from this regional climatic trend which are reflected in local vegetation patterns. The influence of chinooks in major river valleys, which are oriented from east to west, causes considerable local variation in winter climatic conditions.

Available climatic data are analyzed below.

4.1 Climatic Conditions During the Growing Season (May 1 - September 30)

4.1.1 Temperature

Mean daily temperatures during the growing season range from 12.2°C to 7.6°C, decreasing by about 0.9°C per 1 000 m of elevation (Figure 156). This regional pattern is reflected in a shift from deciduous-dominated to coniferous-dominated forests as elevation increases.

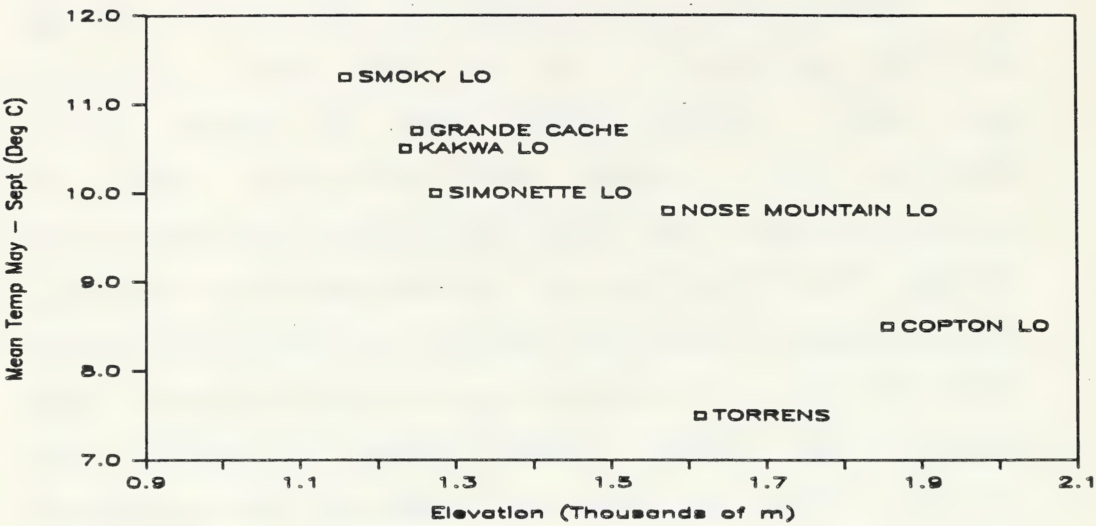

Figure 156: Mean Summer Temperature vs Elevation

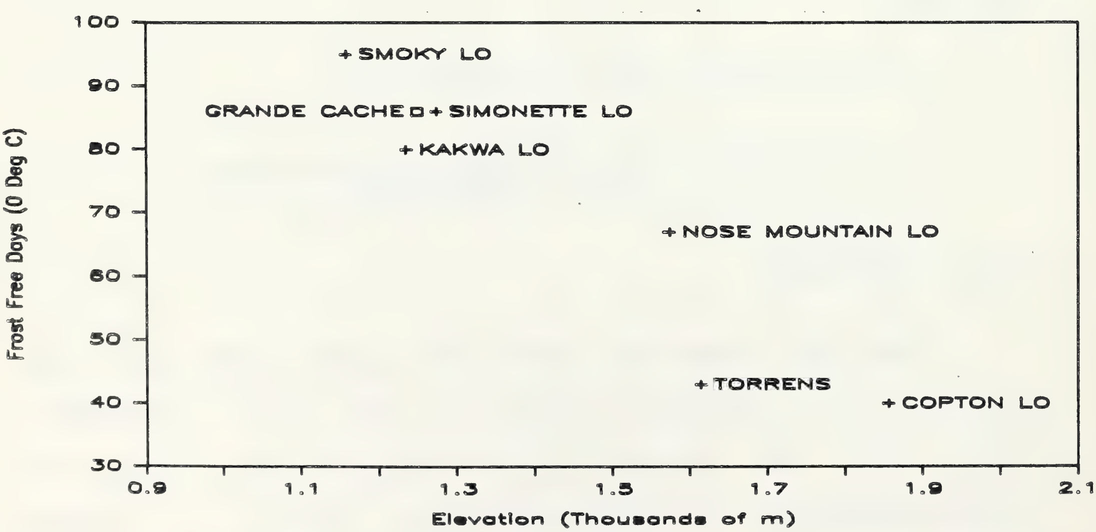

Figure 157: Frost Free Days vs Elevation

Slope and aspect cause significant variation in the regional temperature (and available moisture) pattern in areas of high relief. At a slope of 30%, for example, a southwest exposure receives 15% more solar energy in summer than a northeast exposure; in winter, the difference rises to 20-25%. This brings about higher minimum and maximum air temperatures, higher soil temperatures and lower soil moisture, a less shallow snowpack and earlier snowmelt on slopes exposed to the southwest. As a result, a given vegetation type will occur at higher elevations on southern exposures, although some types may be excluded due to the dryness of these slopes.

Topography also influences the regional climate. For example, the South Wapiti ranger station is cooler on average than the Economy and Bald Mountain lookout towers despite its lower elevation (Appendix E). The South Wapiti Ranger Station is located on a long concave slope that is subject to cold air drainage, while cold air drains away from the ridgetops on which the lookout towers are located.

4.1.2 Frosts

The length of the frost-free period (consecutive days above 0°C, screen height) at forestry lookout towers decreases from 112 days (Economy Lookout) to 40 days (Copton Lookout) as elevation increases (Figure 157). Elevation cannot be used to predict the frost-free period accurately because of local topographic influences. There is nearly as much variation among frost-free periods at the three lowest stations (Economy Lookout, Debolt and South Wapiti Ranger Stations) as there is across the entire study area.

4.1.3 Growing Degree Days

Growing degree days is a measure of heat input that is used to predict plant growth. It is a cumulative measurement of mean daily temperatures above 5°C for the period May 1 to September 30.

Values for growing degree days are generally low compared to the rest of the province. Three stations have climates that impose a moderate heat limitation to the production of tilled crops (1 050-1 300 growing degree days, Strong and Leggat, 1981); Bald Mountain and Economy Lookouts and the Debolt Ranger Station. The limitation to the production of tilled crops is severe at the remaining stations.

4.1.4 Precipitation

Precipitation during the growing season accounts for 60-70% of annual totals and varies from 220 mm at Copton Lookout to 602 mm at Nose Lookout. In general, precipitation increases at higher elevations (Figure 158), but the relationship becomes less well defined in areas of high relief. For example, the Narraway and upper Kakwa river valleys seem to lie in a partial rain shadow.

High variability in summer rainfall because of thunderstorms is a striking characteristic of the regional climate. An average of 25-30 thunderstorms are recorded per year (Lawford 1970), with the frequency of lightning strikes indicating that they are more common the eastern part of the study area (Stashko 1972). Storms yielding as much as 170 mm of rain in one day can be expected once in 25 years (Dupuis, pers. comm.)[1]

[1] Dupuis, S. Climatologist. Resource Appraisal Section, Alberta Energy and Natural Resources

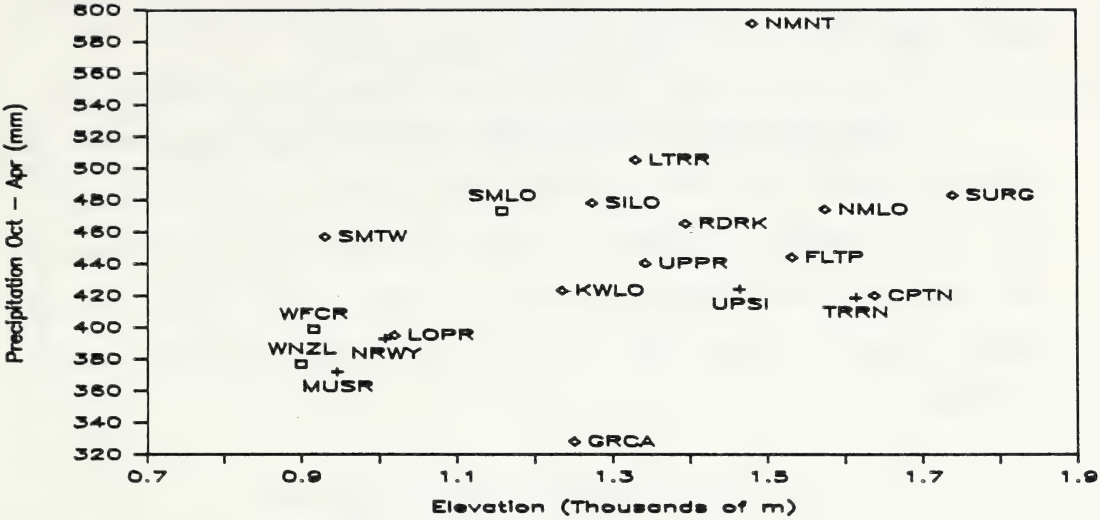

Figure 158: Summer Precipitation vs Elevation

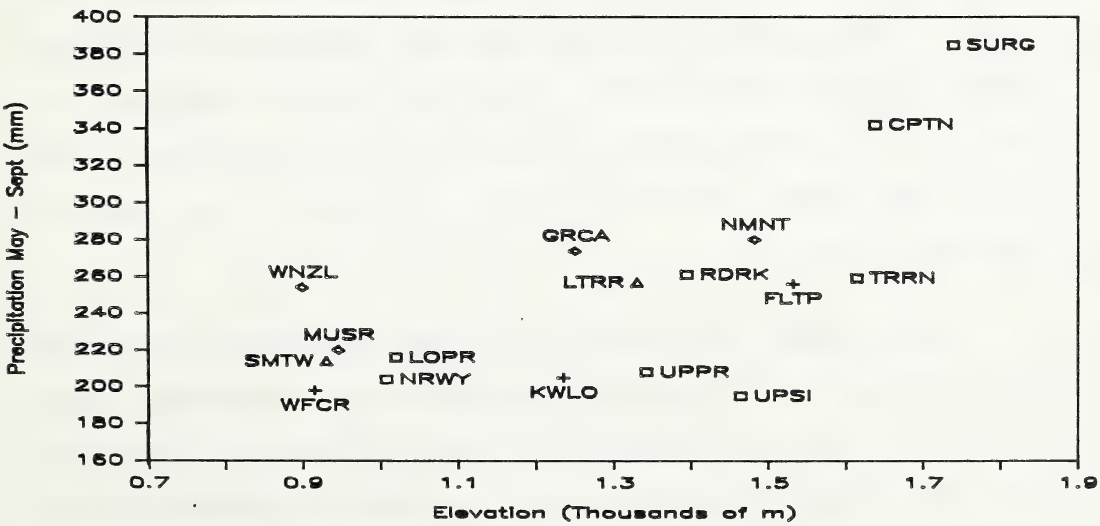

Figure 159: Winter Precipitation vs Elevation

and yields of 40-50 m m/day would be considered normal highs in any given year. Such intensive rainfall contributes to the high silt loads carried by streams and rivers for much of the growing season.

Storm tracks tend to follow major river valleys from southwest to northeast rather than crossing major ridge systems. This accounts for the higher frequency of lightning strikes in the eastern part of the area and suggests that precipitation will be higher in the valleys of the Smoky, Kakwa, Cutbank and Wapiti rivers than elevation would indicate.

4.2 Climatic Conditions During the Winter (October 1 to April 30)

Based on observations elsewhere on the Eastern Slopes, winter temperatures of -11.5°C to -23°C (February-March) are expected on the low-lying Wapiti Plains in the northern part of the area (Strong and Leggat 1981). Approaching treeline, expected temperatures rise to -7°C to -12°C (February-March) as higher topography deflects cold Arctic air masses moving in from the north. Above treeline, mean temperatures of -14°C to -15°C (February-March) are typical of the Eastern Slopes. Cold winter temperatures are modified locally by chinooks in the Smoky and Kakwa river valleys.

Mean winter precipitation varies more than twofold across the area from less than 180 mm to more than 360 mm water equivalent. There is a trend of increasing snowfall with increasing elevation (Figure 159), but local variation is great in areas of high relief because of the rainshadow effect. Accumulated snow depth is also highly variable because of local variation in packing, melting, redistribution by wind

and gravity, and sublimation.

Data from nine forestry lookout towers, two ranger stations and 18 Sacramento precipitation gauge stations appear in Appendix E. Also included are limits for climatic parameters in each ecoregion.

5. HYDROLOGY

5.1 Rivers

The study area lies wholly within the Smoky River drainage basin, which is part of the Peace River system. It is drained by six major rivers: the Smoky, Kakwa and Wapiti/Narraway rivers, originating in the Rocky Mountains and Foothills, and the Cutbank, Little Smoky and Simonette/Lookout orginating in the Western Alberta Plains (Figure 160). The rivers exhibit significant differences in hydrological response as described below.

5.1.1 Seasonality of Discharge

Discharge data (Environment Canada, 1980a) show that rivers originating in the Rocky Mountains and Foothills tend to have later peak flows than rivers that arise in the Western Alberta Plains, because lower average temperatures at higher elevations lead to later snowmelt (Figure 160).

Despite this general relationship, however, the timing of peak flow is quite variable. All of the rivers in the study area are prone to flash-flooding during periods of especially high rainfall in summer. In 1976, for example, peak flows were recorded in August in all of these rivers (Environment Canada, 1980a).

5.1.2 Mean Discharge Rates

Mean discharge rates during the period May-October vary from 10.1 to 618.2 m^3/sec among the rivers in the study area (Table 29).

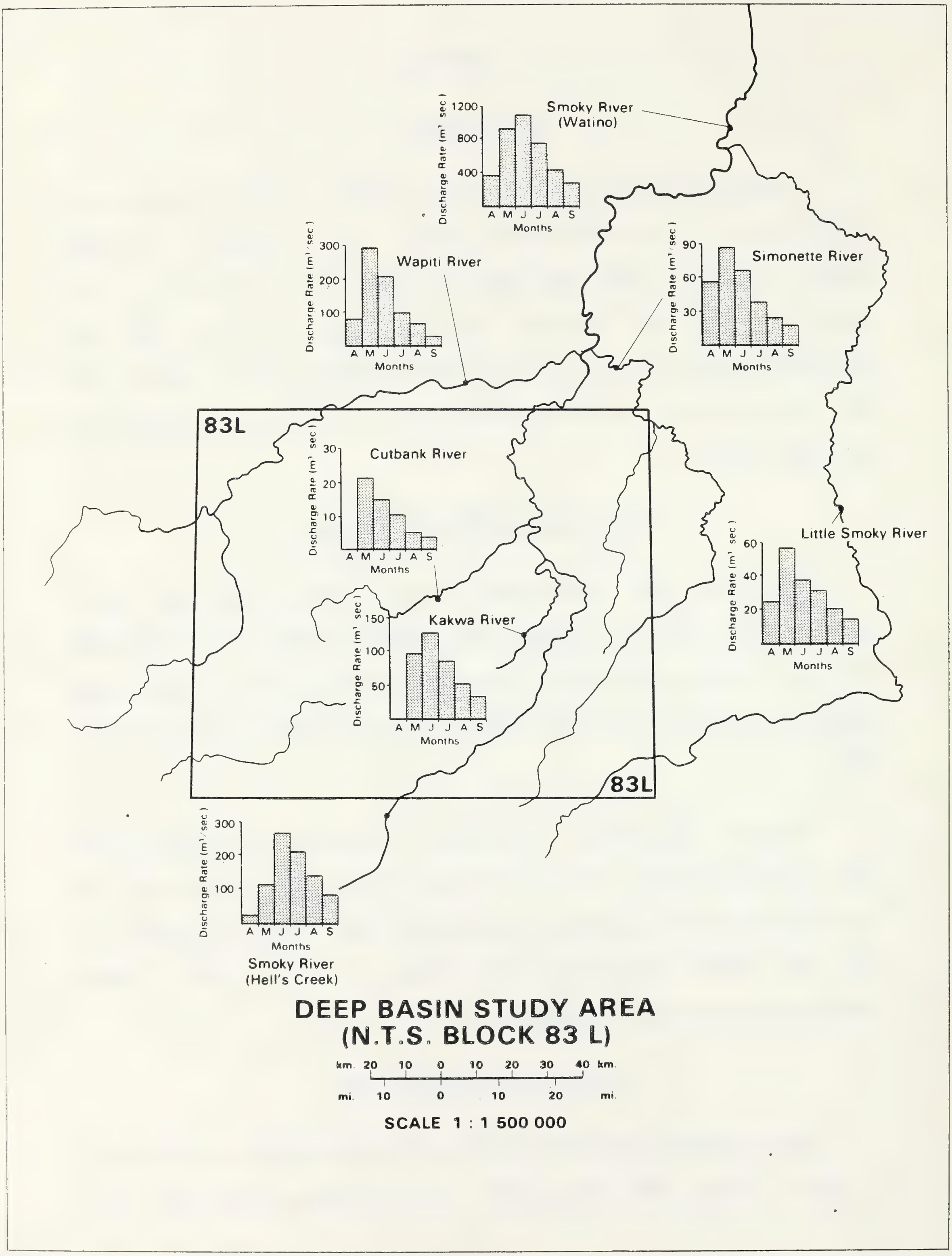

Figure 160: Major Rivers and their Annual Hydrographs

Differences in the sizes of drainage basins and precipitation regimes are the cause of this pattern. The Smoky, Kakwa and Wapiti/Narraway rivers which originate in the Rocky Mountains and Foothills have much higher mean discharge rates per unit of basin area than the rivers that have their headwaters at lower elevations.

Table 29

MEAN DISCHARGE RATES OF RIVERS

Station	Basin Area (km^2)	Mean Discharge May-October (m^3/sec)	Mean Discharge (m^3/sec/) 100 km^2
Smoky (Hell's Creek)	3 830	142.9	3.76
Kakwa	3 290	68.8	2.09
Wapiti	11 300	180.8	1.60
Smoky (Watino)	50 200	618.2	1.23
Cutbank	842	10.1	1.19
Little Smoky	3 000	28.0	0.93
Simonette	5 000	41.0	0.82

Source: Environment Canada 1980a

5.1.3 Water Quality

All of the rivers in the study area tend to carry relatively high silt loads, especially during periods of peak flow. Total hardness ranges from 98-391 mg/L and often exceeds the upper limit of 120 mg/L considered suitable for domestic consumption, especially during periods of low flow. Concentration of major and minor ions in river water are within the limits proscribed for domestic use (Environment Canada 1980b, 1982).

5.2 Lakes

The highest density of lakes and ponds is found on the Wapiti Plains in the northern part of the study area. These water bodies are relatively small and shallow, occupying small basins underlain by fine-textured tills, glaciolacustrine deposits, and bedrock. The orientation of many of these basins relative to coarse-textured outwash deposits suggests that groundwater is a significant component of the hydrologic input to these lakes and ponds.

Lakes and ponds are much less common in the Western Alberta Plains, Rocky Mountain Foothills and Rocky Mountains. Musreau Lake is the largest water body in this part of the study area. It is unique for the region, a remnant of a much larger lake that existed in glacial times.

A number of small lakes are found in old outwash and meltwater channels. Two Lakes, found at the headwaters of Gunderson and Stetson Creeks, are the largest lakes of this type. Others include Boundary, Trap and Chinook Lakes in the western part of the study area. Smaller lakes have developed in meltwater channels in the southeastern corner of the study area (Twp. 59, Rge. 2, 3).

Small kettle-like and drift basin lakes are also scattered throughout the Western Alberta Plains and Rocky Mountain Foothills on till deposits.

5.3 Groundwater

5.3.1 Flow Rates

Groundwater supplies in the area have been described by Barnes (1977). Depth to groundwater increases from east to west, from 15 m or less on the Deep Valley Plateau east of the Simonette River to 150 m or more on the dissected Western Alberta Plains and Rocky Mountain Foothills.

High groundwater flow rates are restricted to fracture zones in the bedrock because of the low porosity of the Paskapoo and Wapiti formation. Wells that intersect fracture zones yield 50-100 instantaneous gallons per minute (igpm) in the Western Alberta Plains, and up to 1 500 igpm in the Rocky Mountain Foothills. By way of contrast, wells outside of fracture zones yield less than 5 igpm, and surficial aquifers like outwash gravels yield 10-50 igpm.

5.3.2 Water Quality

The quality of groundwater supplies is generally high in the Rocky Mountain Foothills and Western Alberta Plains, with total dissolved solids ranging from 300-500 mg/L. Higher concentration of total dissolved solids in groundwater on the Wapiti Plains (900-1 000 mg/L) exceed the limit of 500 mg/L prescribed for domestic consumption (McNelley *et al*. 1979).

6. VEGETATION

Within the Deep Basin study area, fire has played a significant role in the development of the current vegetation. Recurrent fires within the past century have resulted in a mosaic of coniferous, deciduous and mixedwood forests. The aging of trees indicates that most stands originated following three major episodes of fire within the study area; 1880-1900, 1915-1925 and 1930-1940. These dates appear to correspond to unusually dry summer conditions (Hage, 1984).

The forest vegetation in the area shows a zonation pattern which is a result of the climatic changes with increasing elevation. The forest pattern changes from aspen forest at lowest elevations to lodgepole pine at mid elevations with Engelmann spruce and alpine fir at higher elevations. Alpine meadows occur at the highest elevations where the climate is too severe for tree species to survive.

The zonal pattern of vegetation is further influenced by variation in parent materials and drainage. The lower elevation aspen forests ocur on moderately well-drained glaciolacustrine sediments and, to some extent, on morainal deposits. These stands have a relatively lush understory of shrubs such as rose and low-bush cranberry with a variety of herb and grass species. Balsam poplar is present on the more moist sites with its abundance increasing with increasing moisture. These stands would eventually succeed to white spruce, however, frequent fires have resulted in the dominance of early successional stages. Lodgepole pine forests are found at low elevations on rapidly drained eolian and glaciofluvial materials. The understory of these stands is relatively

sparse with lichens often present, indicating the dry site conditions. These sites will probably remain as lodgepole pine as other species cannot tolerate these dry site conditions. Wetter sites at low elevations support black spruce, tamarack, shrublands and sedge meadows.

The lodgepole pine forests at mid elevations occur dominantly on morainal materials with some occurrence of residual and colluvial materials. The understory in the pine stands change with increasing elevation. Lower elevations have relatively lush understories of low-bush cranberry and a variety of herbs while the upper elevation have understories of ericaceous shrubs and feathermosses which reflects the cooler climate. These stands have developed as a result of fires and would eventually succeed to white or Engelmann spruce with Engelmann spruce at higher elevations. Black spruce becomes a component of the pine stands on the wetter locations and occurs alone on the wettest sites.

The high elevation Engelmann spruce-alpine fir stands appear to develop in response to a cooler climate which reduces the incidence of fires. The understory vegetation is restricted to ericaceous shrubs and mosses at these elevations. Materials here are often colluvial with moraine and residual relatively common. These Engelmann spruce-alpine fir forests become more open with increasing elevation. The transition area to the alpine meadows supports krummholtz vegetation of Engelmann spruce and alpine fir.

The alpine meadows develop under a severe climatic regime which only a few plant species can tolerate. Willow shrublands develop in

in protected locations, sedge meadows dominate in moist areas and species poor, lichen dominated communities occur in exposed locations. Much of this area has very shallow soils which further restricts plant growth.

The broad vegetation patterns described here are classified into ecoregions which are defined as climatic zones inferred by vegetation. These ecoregions are described in detail in Volumes I and II of this report.

7. FAUNA

The Deep Basin area supports a wide variety of fauna including big game, furbearers, fish and, to a lesser extent, waterfowl and upland game birds. Species diversity is enhanced by the wide range of ecological conditions that exist within the area.

7.1 Big Game

Big game species within the study area include moose, elk, caribou, mule deer, white-tail deer, bighorn sheep, mountain goat, grizzly and black bear, and cougar. Big game populations are considered to exhibit good productivity.

Big game habitat is closely associated with physiognomic structure of the vegetation and to a lesser extent topography. The edge of the forests and riparian zones are utilized to a greater degree by big game animals (except caribou) than the forest itself.

In the northern third of the study area mixedwood and deciduous forests with rich, moist herbaceous understories provide year-round habitat for white-tail deer, mule deer and to a lesser extent elk, moose and black bear. Poorly drained deciduous shrublands which occur throughout the study area provide year-round moose habitat and wintering habitat for elk and mule deer. In the southern portion of the study area open coniferous forests and subalpine meadows at higher elevations provide summer range for elk, moose, mule deer and grizzly bear and wintering range for bighorn sheep and mountain goats. In the extreme western and southwestern portion of the study area, climax coniferous

forest and adjacent open areas with abundant lichen and moss cover provide year-round caribou habitat. Bighorn sheep prefer alpine meadows and rocky escape terrain in proximity to open stands of grass and shrubs. Steep grassy slopes close to the treeline with nearby rock outcrops for escape terrain provide suitable habitat for mountain goats.

Rugged, subalpine and alpine wilderness areas where open, unforested areas exist are the preferred habitat of the grizzly bear. Black bears, although well suited to the habitat of the study area, are found in greater abundance in other Eastern Slope regions due to their adverse relationship with the grizzly bear (Lynch, pers. comm).[2] They are more common and wide-spread in areas of less rugged terrain.

Cougars prefer dense cover on rocky rugged terrain. The most consistent habitat feature is the presence of mule deer. Populations are presently well below carrying capacity but this species is not considered to be rare or endangered.

Closed coniferous forests, although utilized by caribou, are not considered to be valuable habitat due to sparse understory composition. These communities are primarily used for shelter and travel, especially in the winter when the depth of snow prohibits movement in open areas. Moose, elk, mule deer and caribou better exploit their habitat for foraging further away from their escape terrain than do bighorn sheep, mountain goats and white-tail deer. Major wintering habitats for big game animals include broad river valleys and steep southeast exposures

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[2] Lynch, G. Alberta Energy and Natural Resources, Fish and Wildlife Division, Edmonton, Alberta.

such as those found along the Smoky, Kakwa, Narraway, Wapiti, Cutbank, Simonette and Latornell river valleys.

Key wildlife areas have been identified by the Fish and Wildlife Division of Alberta Energy and Natural Resources for caribou, elk, mountain goat, bighorn sheep, moose, mule and white-tailed deer, and grizzly bear. Key wildlife habitats have been defined as habitat areas which are critical to a significant number of individuals of a species during at least a part of the year. Key wildlife habitats for moose and elk are shown in Figure 161. Figure 162 shows key wildlife areas for caribou, bighorn sheep, mountain goats, mule deer and white-tailed deer. Key grizzly habitat is shown on Figure 163. It should be noted that these maps are subject to periodic update.

7.2 Furbearers

The following terrestrial furbearers are found within the study area: pine marten, fisher, wolverine, lynx, coyote and wolf. Coyote and wolf are often referred to as furbearing carnivors. Semi-aquatic furbearers include beaver, mink and muskrat.

Pine marten are associated with climax spruce-fir or pine communities adjacent to spruce-fir stands. Optimum fisher habitat includes uneven-aged mixedwood forests with good interspersion of conifer stands and tall shrubs. Dense wolverine populations ($1/km^2$) are associated with closed coniferous forests and the ranges of either caribou or large diverse ungulate populations (Todd, 1978).

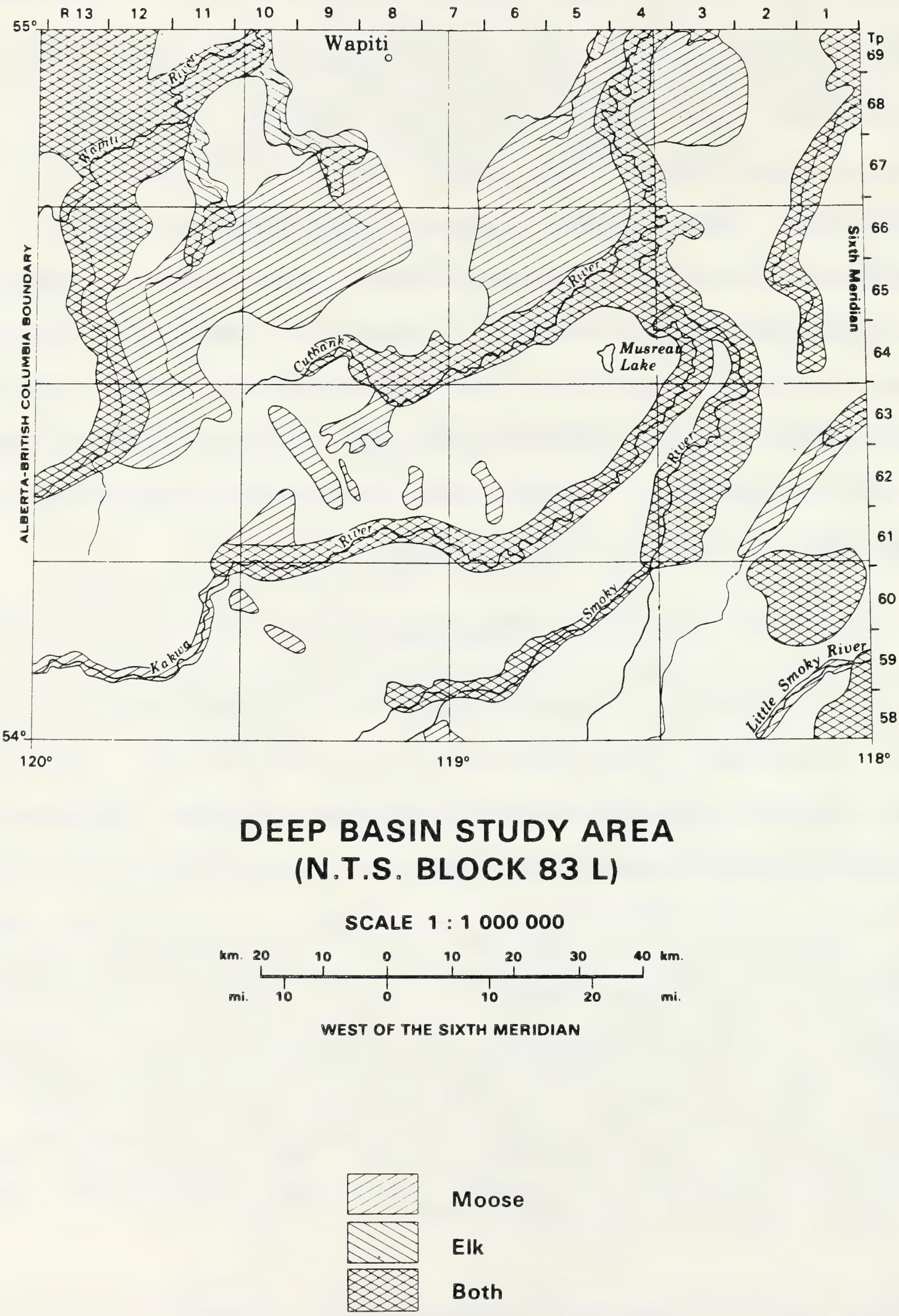

Figure 161: Key Wildlife Areas for Moose and Elk

Source: Fish and Wildlife Division, Alberta Energy and Natural Resources, 1983

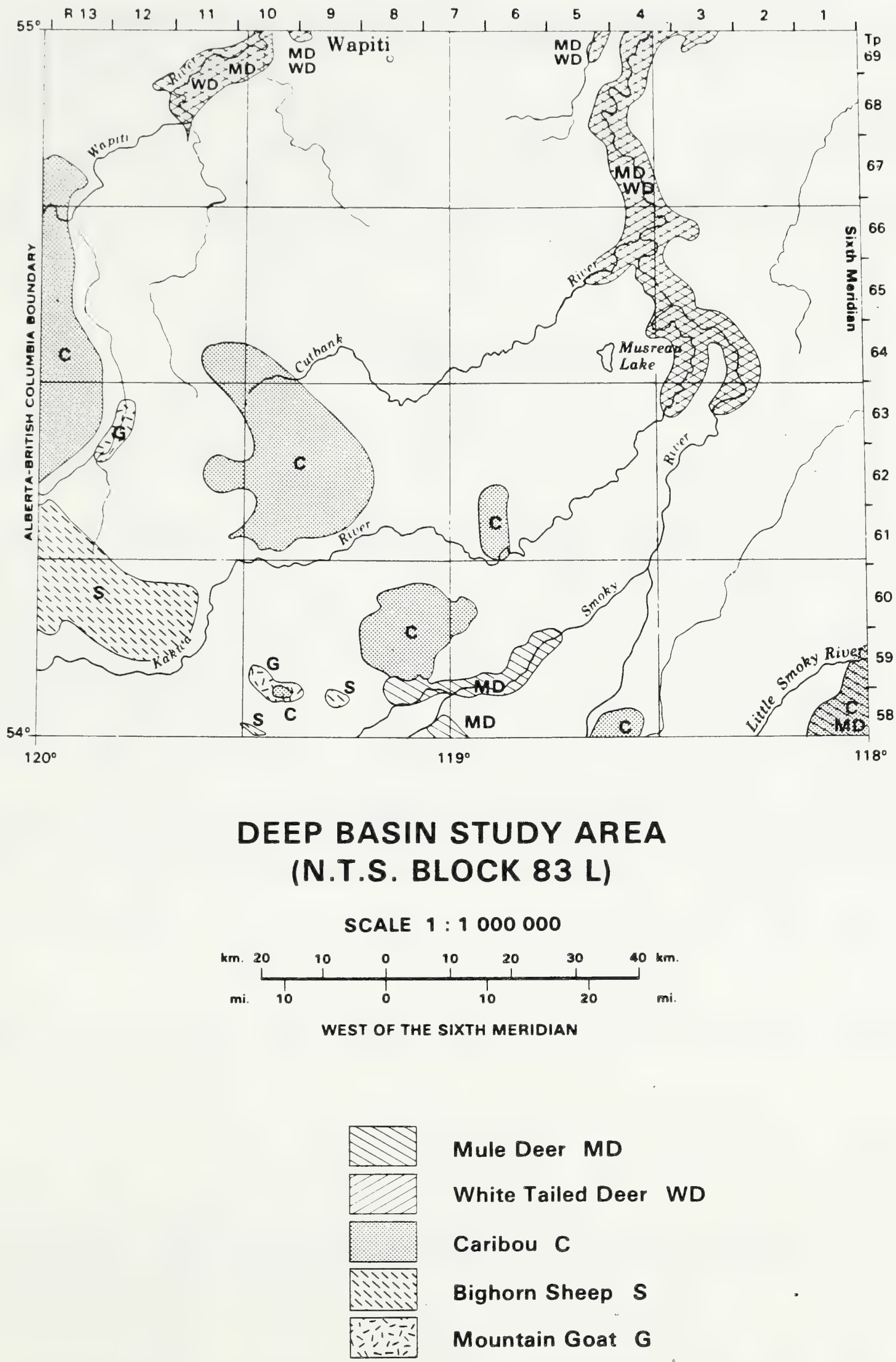

Figure 162: Key Wildlife Areas for Mule Deer, White Tailed Deer, Caribou, Bighorn Sheep, and Mountain Goats

Source: Fish and Wildlife Division, Alberta Energy and Natural Resources, 1983

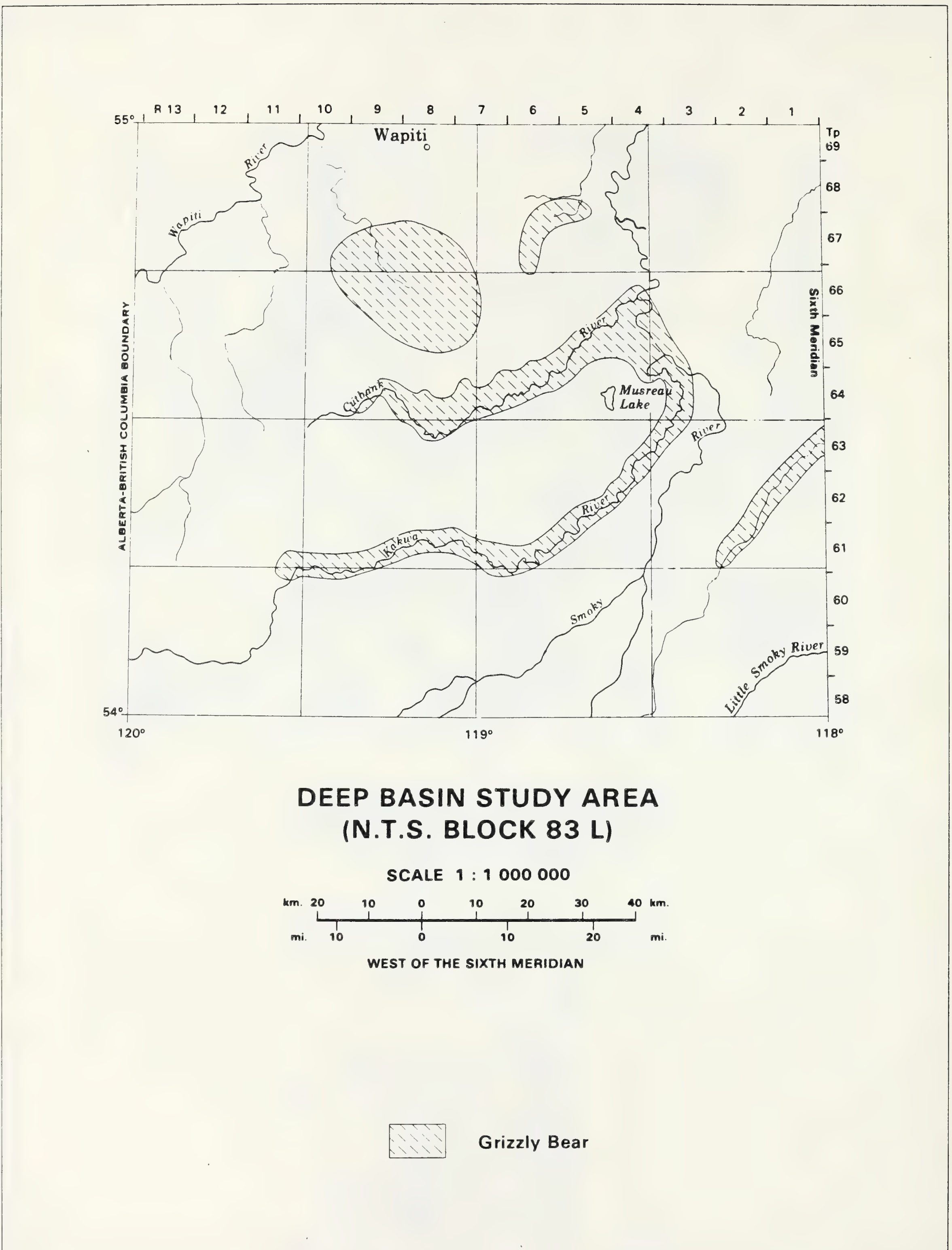

Figure 163: Key Wildlife Areas for Grizzly Bear

Source: Fish and Wildlife Division, Alberta Energy and Natural Resources, 1983

Lynx, coyote and wolf also occur within the study area, but very little information has been collected on these species due to their large territory requirements.

Beaver, muskrat and mink are generally restricted to the northern portion of the study area where streamflow rates are reduced and coarse gravelly substrate materials are absent.

7.3 Fishery Resources

Although productivity levels are generally low, healthy populations of arctic grayling, dolly varden and mountain whitefish are native to the study area (Hunt, pers. comm.).[3] Rainbow trout have been stocked in Two Lakes (Twp. 62, Rge. 12, W6M) and Unnamed (Long) Lake (Twp. 63, Rge. 5, W6M). Low productivity levels may be attributed to cold stream temperatures.

The Cutbank, Wapiti, Narraway and Kakwa (below Kakwa Falls) Rivers support dolly varden, arctic grayling and mountain whitefish populations. The Smoky River supports dolly varden and mountain whitefish whereas the Simonette River is reported to have good populations of arctic grayling. The cold, faster flowing streams of the Western Cordillera generally support only small populations of dolly varden (Natural Resources Subcommittee, 1976).

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[3] Hunt, C. Alberta Energy and Natural Resources, Fish and Wildlife Division, Edmonton, Alberta.

7.4 Waterfowl

Waterfowl production within the study area is considered low. Trumpeter swans, harlequin ducks, hooded mergansers and to a lesser extent mallard ducks breed successfully but are generally restricted to the northern portion of the study area. Lack of open water is the major limiting factor to waterfowl production (Anonymous, 1970). The large distance between the study area and major migratory corridors also contributes to low waterfowl populations.

7.5 Upland Game Birds

Common upland game bird species within the study area include ruffed grouse, blue grouse, spruce grouse, rock ptarmigan and white-tailed ptarmigan. Ruffed grouse are commonly associated with mixedwood forests and riparian areas while spruce grouse utilize coniferous dominated mixedwood forests and adjacent organic ares. Blue grouse habitat includes open to closed coniferous forests within the lower to middle subalpine areas. Ptarmigan are found within the upper subalpine and alpine areas of the study area.

8. LAND USE AND ECONOMIC RESOURCES

Although recent economic activities within the Deep Basin/Kakwa Wapiti study area are readily visible to the human eye, a major portion of the study area represents one of the last untouched wilderness areas in Alberta. Outside of a native and forestry operations settlement at Shuttler Flat, no settlements exist within the study area; however, recent agricultural expansion into portions of Township 69 have resulted in a influx of settlers into the extreme northern portion of the study area. The two major, but relatively new communities of Grande Prairie and Grande Cache, are located approximately 15 km north and south of the study area, respectively.

Early economic development within the study area was limited to trapping and local coal and lumber operations. Within the past quarter century major oil and gas activities, coal and gravel extraction, forestry operations and agricultural expansion have resulted in significant modifications to the landscape.

8.1 Forestry Resources

Over the past twenty years extensive forestry operations by both Proctor & Gamble Cellulose Ltd. (P&G) and North Canadian Forest Products (CANFOR) have resulted in significant portions of land being harvested for pulp (P & G) and sawlog (CANFOR) production. Proctor & Gamble is harvesting mainly lodgepole pine from the central and southwestern portions of the study area. Within the past two years, P & G has begun to harvest some mature aspen stands in the north-central portion

of the study area. CANFOR operations have generally been confined to the southeastern portion of the study area where they are harvesting mainly white spruce.

8.2 Mineral Resources

Natural gas, coal and to a lesser extent oil and gravel are considered to be economically important within the Deep Basin study area. Silica sand, clay, concrete and phosphate rock, bentonite and possibly uranium also occur within the study area but are not considered to be economically important. Only those resources considered to be economically viable will be discussed.

8.2.1 Oil and Natural Gas

Oil and gas exploration within the past quarter century have resulted in a mosaic of well sites, refineries, pipelines and seismic lines that criss-cross the entire study area.

Natural Gas. The Deep Basin gas field occurs mostly within the Wapiti Plains and the Western Alberta Plains and extends for some 700 km in a northwest trending belt into British Columbia. The Deep Basin is bounded to the north-northeast by the Lower Cretaceous Fox Creek escarpment and to the south-southwest by the Rocky Mountain Foothills. The Energy Resources Conservation Board (ERCB) (1981) estimated the initial established marketable gas reserves to be 109 billion cubic metres. This represents the largest potential source of natural gas in North America (Sandmeyer, 1980).

Within the Deep Basin study area, eighteen gas fields have been identified by the ERCB (1983), most of which fall within the Deep Basin field.

1.	Elmworth	7.	Newand	13.	Musreau
2.	Wapiti	8.	Karr	14.	Narraway
3.	Gold Creek	9.	Kakwa	15.	Palliser
4.	Cutbank	10.	Route	16.	Network
5.	Bilbo	11.	Lynx	17.	Redrock
6.	Steep	12.	Latornell	18.	Wanyandi

Six gas processing plants occur within the study area and generally reflect the overall importance of this resource to the study area.

Recent activity has focussed on shallow Mesozoic sandstone formations where the greatest portion of natural gas has been discovered in "low permeability" or "tight" formations. The low permeability of these tight formations has not permitted well production rates high enough to be commercially produceable.

Oil. Only three oil fields have been identified within the study area by the ERCB (1983). These fields are the Kakwa, Jayar and Lator (ERCB, 1983).

8.2.2 Coal

Three major coal fields have been identified within the study area by the Energy Resources Conservation Board (Natural Resources Subcommittee, 1976). These include the Musreau Coal Field, the Kakwa River Coal Field and the Smoky River Coal Field, the latter being the only producing coal field in the study area.

The Musreau Coal Field, located within the Interior Plains near Musreau Lake (Twp. 64, Rge. 5, W6M), contains thick Ardley coal seams of the Scollard member of the Paskapoo Formation. This coal is of the sub-bituminous to high volatile type. Ardley coal seams also occur along parts of the lower reaches of the Simonette, Kakwa and Smoky River valleys and within the Nose Mountain, particularly in the vicinity of the Cutbank River.

The Smoky and Kakwa River coal fields occur within the Western Cordillera. The Smoky River coal field is located north of Grande Cache in the vicinity of Sheep Creek and Smoky River. The Kakwa River Coal field includes parts of Torrens Ridge, Coal Ridge and Horn Ridge. The Smoky and Kakwa fields are both part of the Lower Cretaceous Luscar Formation which extends in a northwest-trending belt from the northeastern edge of Jasper National Park into British Columbia. These coals are of the low volatile bituminous type.

Extensive coal mining operations by the Smoky River Coal Company are confined to the area between Sheep Creek and the Smoky River. The coal, which is being mined from the Lower Cretaceous Luscar Formation, is destined mainly for export to Japan. A significant portion of the disturbed land has been reclaimed in recent years.

8.2.3 Gravel

Gravel deposits within the study area, although not extensive, occur mainly as glaciofluvial terraces bordering major drainage channels. Significant deposits can be found along the upper reaches of the Smoky River and the lower reaches of Muskeg River and Sheep Creek. Other major

deposits are found on terraces adjacent to the Wapiti River especially near its confluence with Nose Creek and the area around Lingrell Lake. A small area of Tertiary gravels outcrop along the Forestry Trunk Road, south of the Smoky Fire tower. The above mentioned areas are currently being mined for gravel resources.

8.3 Agriculture

Major portions of Township 69, Ranges 6-12, W6M have been cleared in recent years to provide additional agricultural land. Most of these lands have been cleared for pasture and such crops as barley, hay, canola, wheat and oats.

APPENDIX E

CLIMATIC PARAMETERS FOR SPECIFIC STATIONS WITHIN THE DEEP BASIN AREA

BALD MOUNTAIN LO

54°49'N 118°55'W 939 m

	J	F	M	A	M	J	J	A	S	O	N	D	YR
Daily Maximum Temperature	M	M	M	M	14.6	17.6	20.0	18.9	14.2	M	M	M	M
Daily Minimum Temperature	M	M	M	M	3.9	7.3	9.5	8.6	4.5	M	M	M	M
DAILY TEMPERATURE	M	M	M	M	9.4	12.6	14.8	13.8	9.4	M	M	M	M
Standard Deviation, Daily Temperature	M	M	M	M	1.1	1.1	1.2	1.7	2.7	M	M	M	M
Extreme Maximum Temperature	M	M	M	23.3	28.9	31.1	31.1	31.7	30.0	23.9	M	M	31.7
Years of Record	0	0	0	4	15	16	16	16	14	3	0	0	
Extreme Minimum Temperature	M	M	M	M	-5.0	-3.9	1.7	-3.0	-10.6	-1.7	M	M	M
Years of Record	0	0	0	0	12	16	16	16	15	1	0	0	
Rainfall	M	M	M	M	39.8	89.3	74.8	80.9	55.5	M	M	M	M
Snowfall	M	M	M	M	10.8	0.0	0.0	1.7	7.9	M	M	M	M
TOTAL PRECIPITATION	M	M	M	M	53.2	89.3	74.8	83.3	63.8	M	M	M	M
Standard Deviation, Total Precipitation	M	M	M	0.0	39.4	53.4	51.1	47.2	36.3	11.4	M	M	M
Greatest Rainfall in 24 Hours	M	M	M	18.5	50.8	90.2	85.1	63.2	52.1	11.9	1.3	M	M
Years of Record	0	0	0	6	24	27	26	27	22	5	1	0	
Greatest Snowfall in 24 Hours	M	M	M	21.8	18.3	T	0.0	25.9	13.7	23.4	M	M	M
Years of Record	0	0	0	7	23	27	26	27	22	6	0	0	
Greatest Precipitation in 24 Hours	M	M	M	23.6	50.8	90.2	85.1	63.2	52.1	23.4	M	M	M
Years of Record	0	0	0	7	25	27	26	27	22	7	0	0	
Days with Rain	M	M	M	M	7	11	12	12	9	M	M	M	M
Days with Snow	M	M	M	M	2	0	0	0	2	M	M	M	M
Days with Precipitation	M	M	M	M	9	11	12	12	10	M	M	M	M

COPTON LO

54°11'N 119°24'W 1 856 m

	J	F	M	A	M	J	J	A	S	O	N	D	YR
Daily Maximum Temperature	M	M	M	M	M	10.9	14.1	12.8	M	M	M	M	M
Daily Minimum Temperature	M	M	M	M	M	2.7	5.6	5.0	M	M	M	M	M
DAILY TEMPERATURE	M	M	M	M	M	6.8	9.8	9.0	M	M	M	M	M
Standard Deviation, Daily Temperature	M	M	M	M	0.0	1.4	1.5	2.0	M	M	M	M	M
Extreme Maximum Temperature	M	M	M	M	18.9	24.4	27.2	26.7	16.1	M	M	M	27.2
Years of Record	0	0	0	0	1	16	15	16	2	0	0	0	
Extreme Minimum Temperature	M	M	M	M	M	-5.6	-4.0	-6.1	-10.6	M	M	M	M
Years of Record	0	0	0	0	0	16	16	16	2	0	0	0	
Rainfall	M	M	M	M	M	64.3	77.2	64.7	M	M	M	M	M
Snowfall	M	M	M	M	M	15.0	1.5	8.1	M	M	M	M	M
TOTAL PRECIPITATION	M	M	M	M	M	85.8	78.8	73.8	M	M	M	M	M
Standard Deviation, Total Precipitation	M	M	M	M	70.8	56.7	41.8	39.5	25.6	0.0	M	M	M
Greatest Rainfall in 24 Hours	M	M	M	M	28.4	58.2	48.0	36.8	13.5	8.9	M	M	M
Years of Record	0	0	0	0	6	19	21	19	5	2	0	0	
Greatest Snowfall in 24 Hours	M	M	M	M	22.9	25.9	16.3	42.9	40.9	23.6	M	M	M
Years of Record	0	0	0	0	5	19	22	20	6	2	0	0	
Greatest Precipitation in 24 Hours	M	M	M	M	55.1	85.9	48.0	50.8	49.5	23.6	M	M	M
Years of Record	0	0	0	0	6	19	21	19	6	3	0	0	
Days with Rain	M	M	M	M	M	11	12	12	M	M	M	M	M
Days with Snow	M	M	M	M	M	2	0	1	M	M	M	M	M
Days with Precipitation	M	M	M	M	M	13	12	12	M	M	M	M	M

ECONOMY LO

54°47'N 118°14'W 800 m

	J	F	M	A	M	J	J	A	S	O	N	D	YR
Daily Maximum Temperature	M	M	M	M	15.5	18.5	20.8	19.7	14.9	M	M	M	M
Daily Minimum Temperature	M	M	M	M	3.6	7.1	9.2	8.1	3.9	0.6	M	M	M
DAILY TEMPERATURE	M	M	M	M	9.5	12.8	15.0	14.0	9.5	M	M	M	M
Standard Deviation, Daily Temperature	M	M	M	M	1.3	1.1	1.0	1.6	2.5	0.9	M	M	M
Extreme Maximum Temperature	M	M	M	23.9	29.4	33.3	32.8	32.2	31.1	25.6	14.4	M	33.3
Years of Record	0	0	0	8	19	19	19	18	15	8	1	0	
Extreme Minimum Temperature	M	M	M	M	-6.1	-1.1	2.2	-3.0	-9.4	-7.2	M	M	M
Years of Record	0	0	0	0	19	19	19	18	16	4	0	0	
Rainfall	M	M	M	M	45.5	95.1	84.9	76.8	45.7	20.7	M	M	M
Snowfall	M	M	M	M	6.6	0.0	0.0	1.2	3.2	16.5	M	M	M
TOTAL PRECIPITATION	M	M	M	M	52.3	95.1	84.9	78.7	48.9	35.2	M	M	M
Standard Deviation, Total Precipitation	M	M	M	0.0	31.0	48.2	48.1	42.5	25.9	25.0	M	M	M
Greatest Rainfall in 24 Hours	M	M	M	11.4	31.0	55.1	64.8	72.1	25.4	10.7	3.3	M	M
Years of Record	0	0	0	8	27	27	27	26	23	13	1	M	M
Greatest Snowfall in 24 Hours	M	M	M	22.4	25.1	0.0	0.0	16.8	23.9	45.7	M	M	M
Years of Record	0	0	0	4	27	27	27	27	23	11	0	0	
Greatest Precipitation in 24 Hours	M	M	M	22.4	42.2	55.1	64.8	72.1	30.5	45.7	M	M	M
Years of Record	0	0	0	6	27	27	27	26	23	12	0	0	
Days with Rain	M	M	M	M	9	14	13	13	11	6	M	M	M
Days with Snow	M	M	M	M	1	0	0	0	0	3	M	M	M
Days with Precipitation	M	M	M	M	10	14	13	13	11	8	M	M	M

KAKWA LO

54°25'N 118°58'W 1 213 m

	J	F	M	A	M	J	J	A	S	O	N	D	YR
Daily Maximum Temperature	M	M	M	M	12.1	16.0	18.6	17.5	13.1	M	M	M	M
Daily Minimum Temperature	M	M	M	M	1.9	5.8	8.5	7.8	3.4	M	M	M	M
DAILY TEMPERATURE	M	M	M	M	7.1	10.9	13.6	12.7	8.3	M	M	M	M
Standard Deviation, Daily Temperature	M	M	M	M	1.3	1.1	1.1	1.7	3.0	M	M	M	M
Extreme Maximum Temperature	M	M	M	17.8	27.8	30.0	31.1	31.7	28.3	18.3	M	M	31.7
Years of Record	0	0	0	2	14	17	17	16	11	3	0	0	
Extreme Minimum Temperature	M	M	M	M	-6.7	-4.0	-1.7	-2.2	-11.4	M	M	M	M
Years of Record	0	0	0	0	13	16	17	16	12	0	0	0	
Rainfall	M	M	M	M	43.2	104.1	87.3	95.4	51.7	M	M	M	M
Snowfall	M	M	M	M	17.6	2.5	0.0	2.3	17.9	M	M	M	M
TOTAL PRECIPITATION	M	M	M	M	62.9	106.6	87.3	98.1	68.3	M	M	M	M
Standard Deviation, Total Precipitation	M	M	M	M	47.7	59.0	47.7	47.1	36.7	13.4	M	M	M
Greatest Rainfall in 24 Hours	M	M	M	13.2	52.9	111.3	66.0	50.5	34.8	9.7	M	M	M
Years of Record	0	0	0	7	21	25	25	25	20	5	0	0	
Greatest Snowfall in 24 Hours	M	M	M	31.5	41.9	17.5	0.0	26.4	35.6	21.3	M	M	M
Years of Record	0	0	0	5	21	25	25	25	20	4	0	0	
Greatest Precipitation in 24 Hours	M	M	M	31.5	52.9	111.3	66.0	50.5	36.3	21.3	M	M	M
Years of Record	0	0	0	5	20	25	25	25	20	5	0	0	
Days with Rain	M	M	M	M	9	14	12	13	10	M	M	M	M
Days with Snow	M	M	M	M	9	14	12	13	10	M	M	M	M
Days with Precipitation	M	M	M	M	11	14	12	13	11	M	M	M	M

NOSE MOUNTAIN LO

54°33'N 119°35'W 1 574 m

	J	F	M	A	M	J	J	A	S	O	N	D	YR
Daily Maximum Temperature	M	M	M	M	M	14.3	16.4	15.7	11.5	M	M	M	M
Daily Minimum Temperature	M	M	M	M	M	4.5	7.0	6.6	3.1	M	M	M	M
DAILY TEMPERATURE	M	M	M	M	M	9.4	11.8	11.1	7.2	M	M	M	M
Standard Deviation, Daily Temperature	M	M	M	M	0.8	1.3	1.1	1.6	2.6	M	M	M	M
Extreme Maximum Temperature	M	M	M	M	25.0	28.9	28.9	28.3	26.7	15.6	M	M	28.9
Years of Record	0	0	0	0	8	22	22	22	14	2	0	0	
Extreme Minimum Temperature	M	M	M	M	-5.0	-4.4	0.0	-6.0	-13,9	-10.0	M	M	M
Years of Record	0	0	0	0	3	20	22	22	16	1	0	0	
Rainfall	M	M	M	M	M	113.1	116.7	99.6	42.9	M	M	M	M
Snowfall	M	M	M	M	M	6.6	0.0	5.8	23.8	M	M	M	M
TOTAL PRECIPITATION	M	M	M	M	M	120.9	116.7	105.3	76.5	M	M	M	M
Standard Deviation, Total Precipitation	M	M	M	M	105.0	73.8	57.1	56.5	44.8	0.0	M	M	M
Greatest Rainfall in 24 Hours	M	M	M	M	91.0	125.0	69.3	52.1	43.7	11.4	M	M	M
Years of Record	0	0	0	0	6	26	26	28	19	4	0	0	
Greatest Snowfall in 24 Hours	M	M	M	M	48.3	30.0	0.0	37.1	50.8	102.9	M	M	M
Years of Record	0	0	0	0	9	26	26	28	18	5	0	0	
Greatest Precipitation in 24 Hours	M	M	M	M	91.0	125.0	69.3	52.1	50.8	102.9	M	M	M
Years of Record	0	0	0	0	7	26	26	28	19	4	0	0	
Days with Rain	M	M	M	M	M	13	14	12	7	M	M	M	M
Days with Snow	M	M	M	M	M	1	0	1	3	M	M	M	M
Days with Precipitation	M	M	M	M	M	13	14	13	10	M	M	M	M

PINTO LO

54°47'N 119°24'W 1 067 m

	J	F	M	A	M	J	J	A	S	O	N	D	YR
Daily Maximum Temperature	M	M	M	M	13.7	17.0	19.3	18.1	13.7	M	M	M	M
Daily Minimum Temperature	M	M	M	M	2.9	6.7	9.0	8.0	4.2	M	M	M	M
DAILY TEMPERATURE	M	M	M	M	8.3	11.9	14.1	13.1	9.0	M	M	M	M
Standard Deviation, Daily Temperature	M	M	M	M	1.2	1.2	1.2	1.7	2.5	0.0	M	M	M
Extreme Maximum Temperature	M	M	M	19.4	28.9	31.1	31.1	31.1	27.8	22.2	M	M	31.1
Years of Record	0	0	0	3	14	16	16	16	13	4	0	0	
Extreme Minimum Temperature	M	M	M	M	-5.0	-1.1	2.2	-1.7	-9.4	-3.3	M	M	M
Years of Record	0	0	0	0	12	16	16	16	14	1	0	0	
Rainfall	M	M	M	M	50.1	103.2	188.6	88.4	54.3	M	M	M	M
Snowfall	M	M	M	M	9.8	0.5	0.0	3.1	6.9	M	M	M	M
TOTAL PRECIPITATION	M	M	M	M	59.9	103.8	188.6	193.2	63.7	39.4	M	M	M
Standard Deviation, Total Precipitation	M	M	M	M	41.4	59.5	46.0	52.4	31.7	32.4	M	M	M
Greatest Rainfall in 24 Hours	M	M	M	11.4	35.9	171.1	61.0	67.1	42.2	15.7	2.0	M	M
Years of Record	0	0	0	5	19	20	22	22	18	9	1	0	
Greatest Snowfall in 24 Hours	M	M	M	27.9	38.1	7.6	0.0	30.5	24.4	30.5	M	M	M
Years of Record	0	0	0	6	19	20	22	22	18	9	1	0	
Greatest Precipitation in 24 Hours	M	M	M	27.9	38.1	1 7.6	0.0	30.5	24.4	130.5	M	M	M
Years of Record	0	0	0	6	20	20	22	22	19	8	0	0	
Days with Rain	M	M	M	M	8	12	13	13	10	M	M	M	M
Days with Snow	M	M	M	M	2	0	0	0	2	M	M	M	M
Days with Precipitation	M	M	M	M	9	12	13	13	11	M	M	M	M

SIMONETTE LO

54°14'N 118°25'W 1 274 m

	J	F	M	A	M	J	J	A	S	O	N	D	YR
Daily Maximum Temperature	M	M	M	M	11.6	15.3	18.0	16.9	12.4	M	M	M	M
Daily Minimum Temperature	M	M	M	M	1.6	5.6	8.2	7.3	3.3	M	M	M	M
DAILY TEMPERATURE	M	M	M	M	6.6	10.5	13.1	12.1	7.9	M	M	M	M
Standard Deviation, Daily Temperature	M	M	M	M	1.4	1.3	1.3	1.8	2.2	1.1	M	M	M
Extreme Maximum Temperature	M	M	M	M	27.8	29.4	30.0	30.6	27.8	20.6	M	M	30.6
Years of Record	0	0	0	0	11	16	16	16	15	4	0	0	
Extreme Minimum Temperature	M	M	M	-6.7	-7.0	-2.8	1.1	-3.3	-10.0	-16.1	M	M	M
Years of Record	0	0	0	1	6	16	16	16	16	2	0	0	
Rainfall	M	M	M	M	46.0	116.9	106.7	104.4	58.1	14.1	M	M	M
Snowfall	M	M	M	M	21.8	2.6	0.0	2.3	18.1	57.0	M	M	M
TOTAL PRECIPITATION	M	M	M	M	67.1	119.6	106.7	107.4	77.4	47.0	M	M	M
Standard Deviation, Total Precipitation	M	M	M	M	64.0	58.7	58.9	51.6	45.0	30.2	M	M	M
Greatest Rainfall in 24 Hours	M	M	M	M	49.0	188.9	56.6	57.2	36.1	25.7	M	M	M
Years of Record	0	0	0	0	16	24	24	25	24	9	0	0	
Greatest Snowfall in 24 Hours	M	M	M	21.1	52.0	17.8	0.0	16.5	38.6	23.1	M	M	M
Years of Record	0	0	0	2	14	25	24	25	25	7	0	0	
Greatest Precipitation in 24 Hours	M	M	M	21.1	57.0	88.9	56.6	57.2	47.0	25.7	M	M	M
Years of Record	0	0	0	2	13	24	24	25	24	8	0	0	
Days with Rain	M	M	M	M	8	14	14	15	11	2	M	M	M
Days with Snow	M	M	M	M	4	1	0	0	3	7	M	M	M
Days with Precipitation	M	M	M	M	10	14	14	15	12	7	M	M	M

SMOKY LO

54°24'N 118°18'W 1 158 m

	J	F	M	A	M	J	J	A	S	O	N	D	YR
Daily Maximum Temperature	M	M	M	M	13.5	16.8	19.1	17.9	13.7	M	M	M	M
Daily Minimum Temperature	M	M	M	M	2.9	6.8	9.1	8.4	4.5	M	M	M	M
DAILY TEMPERATURE	M	M	M	M	8.3	11.8	14.1	13.2	9.2	M	M	M	M
Standard Deviation, Daily Temperature	M	M	M	M	1.1	1.2	1.1	1.7	3.2	0.6	M	M	M
Extreme Maximum Temperature	M	M	M	22.2	28.3	30.6	29.4	31.1	28.9	23.9	M	M	31.1
Years of Record	0	0	0	5	14	17	18	18	14	6	0	0	
Extreme Minimum Temperature	M	M	M	-15.0	-5.6	-2.0	1.7	-2.2	-10.0	-6.1	M	M	M
Years of Record	0	0	0	2	15	17	18	18	14	3	0	0	
Rainfall	M	M	M	M	54.8	113.3	111.4	97.5	63.7	M	M	M	M
Snowfall	M	M	M	M	13.1	3.3	0.0	1.4	12.3	M	M	M	M
TOTAL PRECIPITATION	M	M	M	M	68.6	116.9	111.4	98.9	76.8	M	M	M	M
Standard Deviation, Total Precipitation	M	M	M	0.0	44.8	57.0	48.8	47.6	47.1	0.0	M	M	M
Greatest Rainfall in 24 Hours	M	M	M	16.3	38.6	167.3	62.2	62.7	43.9	15.2	M	M	M
Years of Record	0	0	0	8	16	19	19	20	15	6	0	0	
Greatest Snowfall in 24 Hours	M	M	M	20.3	32.0	17.0	T	11.4	28.4	28.4	M	M	M
Years of Record	0	0	0	4	16	19	19	20	16	2	0	0	
Greatest Precipitation in 24 Hours	M	M	M	25.1	38.6	67.3	62.2	62.7	43.9	28.4	M	M	M
Years of Record	0	0	0	5	16	19	19	20	15	5	0	0	
Days with Rain	M	M	M	M	10	16	16	15	11	M	M	M	M
Days with Snow	M	M	M	M	3	0	0	0	3	M	M	M	M
Days with Precipitation	M	M	M	M	11	16	16	15	12	M	M	M	M

SOUTH WAPITI RS

54°56'N 119°12'W 762 m

	J	F	M	A	M	J	J	A	S	O	N	D	YR
Daily Maximum Temperature	-9.5	-2.9	1.2	9.7	16.3	19.6	21.8	20.9	15.9	10.7	0.8	-5.8	8.2
Daily Minimum Temperature	-22.6	-16.8	-12.2	-4.2	1.1	4.9	7.0	5.6	1.5	-3.3	-10.9	-18.0	-5.7
DAILY TEMPERATURE	-16.0	-9.9	-5.5	2.8	8.7	12.3	14.4	13.3	8.6	3.7	-5.1	-11.9	1.3
Standard Deviation, Daily Temperature	6.6	6.4	3.4	2.6	1.1	1.0	1.1	1.4	2.0	1.7	3.7	4.9	1.2
Extreme Maximum Temperature	13.3	18.3	20.6	30.0	30.6	32.8	33.3	32.2	30.0	26.1	21.1	11.7	33.3
Years of Record	12	13	12	14	19	19	19	16	17	17	15	12	
Extreme Minimum Temperature	-47.2	-42.8	-40.6	-26.1	-7.2	-5.0	-3.0	-6.0	-13.3	-23.9	-38.9	-45.0	-47.2
Years of Record	12	13	14	11	18	19	17	17	18	17	14	12	
Rainfall	0.9	3.6	3.0	14.8	46.7	90.4	77.5	76.8	51.6	18.5	4.2	3.0	391.0
Snowfall	39.9	26.3	29.0	14.4	4.7	0.0	0.0	0.8	4.5	15.4	28.2	33.3	196.5
TOTAL PRECIPITATION	41.6	28.8	31.9	29.6	51.3	87.3	77.9	73.6	56.3	36.5	31.9	35.1	581.8
Standard Deviation, Total Precipitation	26.1	15.8	17.3	15.5	35.8	49.9	40.3	51.4	38.4	18.5	19.8	23.7	117.8
Greatest Rainfall in 24 Hours	3.6	6.1	10.2	21.1	33.6	70.4	50.8	64.8	44.5	18.3	8.9	17.6	70.4
Years of Record	12	13	14	15	18	19	18	17	18	18	15	13	
Greatest Snowfall in 24 Hours	20.3	21.3	22.9	25.4	8.9	0.0	0.0	19.8	13.7	38.6	20.3	22.4	38.6
Years of Record	12	13	14	13	17	19	19	18	18	18	14	14	
Greatest Precipitation in 24 Hours	21.8	21.3	26.7	33.8	33.6	70.4	50.8	64.8	44.5	51.2	20.3	23.6	70.4
Years of Record	12	13	14	14	19	19	18	17	18	18	14	14	
Days with Rain	1	3	2	6	10	13	13	13	12	7	2	1	83
Days with Snow	12	9	8	3	1	0	0	0	1	2	7	11	54
Days with Precipitation	13	10	10	8	10	13	13	13	12	9	9	12	132

TORRENS LO

54°Ī1'N 119°53'W 1 829 m

	J	F	M	A	M	J	J	A	S	O	N	D	YR
Daily Maximum Temperature	M	M	M	M	M	10.7	13.8	12.6	8.1	M	M	M	M
Daily Minimum Temperature	M	M	M	M	M	2.7	5.5	5.2	1.9	M	M	M	M
DAILY TEMPERATURE	M	M	M	M	M	6.7	9.7	8.9	5.0	M	M	M	M
Standard Deviation, Daily Temperature	M	M	M	M	M	1.5	1.3	2.1	2.6	M	M	M	M
Extreme Maximum Temperature	M	M	M	M	21.1	24.4	26.7	28.9	22.2	14.4	M	M	28.9
Years of Record	0	0	0	0	3	14	15	15	10	1	0	0	
Extreme Minimum Temperature	M	M	M	M	-6.7	-7.8	-3.0	-6.1	-11.7	-5.0	M	M	M
Years of Record	0	0	0	0	1	15	16	15	6	1	0	0	
Rainfall	M	M	M	M	M	89.3	99.2	67.2	M	M	M	M	M
Snowfall	M	M	M	M	M	17.4	0.6	9.5	M	M	M	M	M
TOTAL PRECIPITATION	M	M	M	M	M	113.3	99.5	80.3	M	M	M	M	M
Standard Deviation, Total Precipitation	M	M	M	M	0.0	76.6	48.2	33.9	21.4	M	M	M	M
Greatest Rainfall in 24 Hours	M	M	M	M	7.1	105.4	64.5	41.1	20.1	3.0	M	M	M
Years of Record	0	0	0	0	2	16	16	14	6	1	0	0	
Greatest Snowfall in 24 Hours	M	M	M	M	9.1	30.7	5.8	48.5	37.8	30.5	M	M	M
Years of Record	0	0	0	0	2	14	16	14	5	1	0	0	
Greatest Precipitation in 24 Hours	M	M	M	M	15.0	105.4	64.5	55.6	47.0	30.5	M	M	M
qears of Record	0	0	0	0	2	16	16	15	6	1	0	0	
Days with Rain	M	M	M	M	M	11	13	13	M	M	M	M	M
Days with Snow	M	M	M	M	M	11	13	13	M	M	M	M	M
Days with Precipitation	M	M	M	M	M	13	13	14	M	M	M	M	M

AFS SACRAMENTO PRECIPITATION GAUGES

	NAME	LAT DDMM	LONG DDDMM	ELEV (M)	FROM YYMM	TO YYMM	FDFP (DAYS)	GDD (MAY -	TEMP SEPT)	TEMP DEC - FEB	PRECIP MAY - SEPT	OCT - APR
R01	Flat Top	5421	11928	1 530	7510	8310	M	M	M	M	453	241
R02	Wolf Creek-Cut Bank	5429	11910	914	7510	8310	M	M	M	M	401	188
R03	Red Rock-Dist. III Camp	5425	11918	1 393	7510	8310	M	M	M	M	475	250
R04	Nose Mountain	5433	11935	1 481	7510	8310	M	M	M	M	602	274
R05	Little Redrock	5425	11915	1 329	7510	8310	M	M	M	M	507	252
R06	Sulphur Range	5411	11943	1 737	7510	8310	M	M	M	M	490	363
R08	Pinto Tower	5447	11925	1 021	7610	8310	M	M	M	M	435	202
R09	Smoky Tower	5420	11826	930	7610	8310	M	M	M	M	474	203
R10	Kakwa	5424	11859	1 234	7610	8310	M	M	M	M	439	197
R11	Torrens Mountain	5419	1941	1 713	7610	8310	M	M	M	M	438	237
R12	Upper Prairie Creek 1	5410	11906	1 341	7610	8310	M	M	M	M	451	200
R13	Lower Prairie Creek 2	5411	11853	1 018	7610	8310	M	M	M	M	395	216
R14	Narraway	5437	11954	1 006	7610	8310	M	M	M	M	412	197
R15	Copton	5407	11932	1 637	7610	8310	M	M	M	M	424	328
R16	Econopmy Tower	5446	11814	853	7610	8310	M	M	M	M	394	193
R17	Musreau Creek	5434	11840	945	7910	8310	M	M	M	M	433	189
R18	Wenzel Creek	5434	11800	899	7910	8310	M	M	M	M	427	221
U09	Upper Simonette	5404	11853	1 463	7710	8310	M	M	M	M	466	192

Alluvial fan:	a cone shaped deposit of alluvium made by a stream where it runs out onto a level plain. The fans generally form where streams issue from mountains upon the lowland.
Alluvium:	material such as clay, silt, sand and gravel deposited by modern rivers and streams.
Anticlines:	a fold that is convex upward or had such an attitude at some stage of development.
Apron:	a relatively gentle slope at the foot of a steeper slope, and formed by materials from the steeper upper slopes.
Ardley coal:	a coal bearing strata commonly found within the Paskapoo Formation of the Interior Plains. Common sequence, from top to bottom consists of coaly shale, bentonite, shales and siltstones, bentonite, coal and shale.
Arete:	an acute and rugged crest of a mountain range, or a subsidiary ridge between mountains.
Aspect:	orientation of the land surface with respect to compass direction.
Association:	groups of communities of definite floristic composition and uniform physiognomy occurring in uniform habitat conditions. Usually named in terms of the dominant overstory and understory plants.
Asymmetric syncline:	a syncline in which one limb dips more steeply than the other.
Bedrock:	consolidated component comprised of elastic materials that are tightly packed or indurated. This includes igneous, metamorphic, sedimentary and consolidated volcanic rock.
Bentonitic:	bentonitic is a clay formed from the decomposition of volcanic ash and is largely composed of the clay minerals montmorillonite and beidellite.
Brunisolic:	an order of soils whose horizons are developed sufficiently to exclude the soils from the Regosolic order, but that lack the degrees or kinds of horizon development specified for soils of the other orders. These soils, which occur

under a wide variety of climatic and vegetative conditions, all have Bm or Btj horizons. The great groups Melanic Brunisol, Eutric Brunisol, Sombric Brunisol, and Dystric Brunisol belong to this order.

Blanket: a mantle of unconsolidated materials thick enough to mask the minor irregularities of the underlying unit but still conforming to the general topography, generally 1 m thick.

Bog: a peat-covered or peat-filled area, generally with a high water table. Since the surface of the peatland is slightly elevated, bogs are either unaffected or partly affected by nutrient-rich groundwaters from the surrounding mineral soils. The groundwater is generally acidic and low in nutrients (ombrotrophic). The dominant materials are sphagnum and forest peat underlain.

Calcareous: containing calcium carbonate $CaCO_3$.

Castellated peaks: castle-like or battlemented shaped peaks.

Chroma: the relative purity, strength, or saturation of a color.

Cirque: a deep, steep-walled recess in a mountain caused by glacial erosion.

Climatic climax: the theoretical community towards which all vegetation succession development within a region is tending. This final stage of development is in equalibrium with the general climate and is self regenerating.

Climax: a plant community of the most advanced type capable of development under and in dynamic equilibrium with the prevailing environment.

Colluvium: a heterogeneous mixture of material that as a result of gravitational action has moved down a slope and settled at its base.

Cols: a saddle or gap across a ridge or between two peaks.

Community: an aggregation of all plants and animals within a specified region of spruce and time.

Conglomerate: a rock composed of rounded pebbles cemented together in a matrix of finer material, sometimes called "puddingstone".

Creep:	slow mass movement of soil and soil material down rather steep slopes primarily under the influence of gravity, but aided by saturation with water and by alternate freezing and thawing.
Cuesta:	a ridge, or belt of hilly land, formed on gently dipping rock strata from the more durable layers, which resist denudation better than the weaker layers and are thus left behind as uplands; it has a gentle dip slope on one side, and a relatively steep scarp on the other.
Daily maximum temperature:	based on a 24-hour period beginning at 8:00 A.M. The mean monthly maximum is simply the average of each daily maximum for the month.
Daily minimum temperature:	based on a 24-hour period beginning at 5:00 P.M. The mean monthly minimum temperature is the average of each daily minimum for the month.
Degree day:	a measure of the departure of the mean daily temperature above $5^{o}C$.
Deglaciation:	the uncovering of an area from glacier ice as result of melting of the glacier.
Dendritic:	a term used of any form which is branching, ramifying or dichotomising, thus giving the appearance of a tree in silhouette.
Deposit:	material left in a new position by a natural transporting agent such as water, wind, ice or gravity or by activity of man.
Dip:	the maximum slope of an inclined stratum of rock, measured from the horizontal.
Dolomite:	a semi-transparent crystalline mineral consisting of the double carbonates of calcium and magnesium.
Dominant species:	a species within a given region, which (i) is large in size, (ii) strongly influences the microclimate of other species, or (iii) controls the flow of mass or production.
Drainage classes:	a seven tiered classification of soil drainage taken from the Canadian System of Soil Classification, 1978.

Drift:	any rock material, such as boulders, till, gravel, sand or clay, transported by a glacier and deposited by or from the ice, or, by or in water derived from the melting of the ice.
Dystric Brunisol:	a great group of soils in the Brunisolic order. The soils may have mull Ah horizons less than 5 cm thick. They have Bm horizons in which the base saturation (NaCl) is usually 65% to 100% of the pH ($CaCl_2$) is usually 5.5 or lower.
Dunes:	wind-built ridges and hills of sand formed in the same manner as snowdrifts.
Edaphic:	(i) of or pertaining to the soil, (ii) resulting from or influenced by factors inherent in the soil or other substrate rather than by climatic factors.
Edaphic climax:	a vegetational climax created by changes in the local topography, soil, water conditions, fire or other disturbances such that the climatic climax cannot develop.
Eluvation:	the removal of soil material in suspension or in solution from a layer or layers of the soil.
"en echelon":	parallel structural features that are offset like the edges of shingles on a roof when viewed from the side.
Eolian:	sediment generally consisting of medium to fine sand and coarse silt particle sizes that are well-sorted, poorly compacted and may show internal structures such as cross-bedding or ripople laminae, or may be massive. Individual grains may be rounded and show signs of frosting. These materials have been transported and deposited by wind action.
Erratic:	transported rock fragment different from the bedrock where it lies. The term is generally applied to fragments transported by glacier ice or by floating ice.
Esker:	a winding ridge of irregularly stratified sand, gravel and cobbles deposited under the ice by a rapidly flowing glacial stream.
Evapotranspiration:	the combined loss of water from a given area by evaporation from the soil surface and by transpiration from the plants.

Eutric Brunisol:	great groups of soils in the Brunisolic order. The soils may have mull Ah horizons less than 5 cm thick and they have Bm horizons in which the base saturation (NaCl) is 100%.
Eutrophic:	having concentrations of nutrients optimal or nearly so for plant or animal growth. It is used to describe nutrient or soil solutions.
Fault:	a fracture or fracture zone along which there has been displacement of the sides relative to one another parallel to the fracture. The displacement may be a few inches or many miles.
Floodplain:	deposits of alluvial as a veneer or blanket over a bedrock or gravel floor which has been cut and/or deposited by the lateral action of a river.
Fluvial:	sediments generally consisting of gravel and sand with some fractions of silt and clay. The gravels are typically rounded and contain interstitial sand. Fluvial sediments are commonly moderately to well-sorted and display stratification, although massive, non-sorted gravels do occur. These materials have been transported and deposited by streams and rivers.
Fold:	a flexure in rocks; that is, a change in the amount of dip of a bed, and also often a change in the direction of dip. If the flexure takes the form of an arch, the fold is termed an anticline, while a flexure in the form of a trough is a syncline.
Frost-free period:	that part of the year between the last frost of spring and the first frost of the fall.
Glacial drift:	all rock material carried by glacier ice and glacial meltwaters or rafted by icebergs. This term includes till, stratified drift and scattered rock fragments.
Glaciofluvial deposits:	material moved by glaciers and subsequently sorted and deposited by streams flowing from the melting ice. The deposits are stratified and may occur in the form of outwash plains, deltas, kames, eskers and kame terraces.
Glaciolacustrine:	to be used where there is evidence that the lacustrine material were deposited in contact with glacial ice.

Gleysol: great group of soils in the Gleysolic order. A thin Ah horizon (8 cm) is underlain by mottled gray or brownish gleyed material or the soil has no Ah horizon. Up to 40 cm of mixed peat or 60 cm of fibric moss peat may occur on the surface.

Gleysolic: an order of soils developed under wet conditions and permanent or periodic reduction. These soils have low chromas, or prominent mottling, or both, in some horizons. The great groups Gleysol, Humic Gleysol and Luvic Gleysol are included in the order.

Gravel: rock fragments 2 mm to 7.5 cm in diameter.

Gray Luvisol: a great group of soils in the Luvisolic order occurring in moderately cool climates, where the mean annual temperature is usually lower than 5.5°C. The soils have developed under deciduous and coniferous forest cover and have an eluviated light-covered surface (Ae) horizon, a brownish illuvial B(Bt) horizon and usually a calcareous C horizon. The solum is base saturated (NaCl extraction). The Ahe horizon, is present, is less than 5 cm.

Great group: a category in the Canadian system of soil classification. It is a traxonomic group of soils having certain morphological features in common and a similar pedogenic environment. Examples are Solonetz, Humic Podzol, Regosol, Gleysol, Fibrisol, etc.

Ground moraine: an unsorted mixture of rock, boulders, sand, silt, and clay deposited by glacial ice. Ground moraine is usually in the form of undulating plains having gently sloping swells, sags and enclosed depressions.

Gully: a channel caused by erosion and the concentrated but intermittent flow of water during and immediately after heavy rains.

Hogsback: sharp anticlinal ridge, decreasing in height at both ends until it runs out. A ridge produced by highly tilted strata.

Homocline: a group of inclined beds of the same dip, which may be either monoclinal, one limb of a fold or isoclinal, but whose actual relations are not determinate. Used in a more restricted sense than a monocline in that it applies to small or fragmentary areas.

Horizon: a layer in the soil profile approximately parallel to the land surface with more or less well-defined characteristics that have been produced through the operation of soil forming processes.

Humic Gleysol: a great group of soils in the Gleysolic order. A dark colored A (Ah or Ap) horizon more than 8 cm thick is underlain by mottled gray or brownish gleyed mineral material. It may have up to 40 cm of mixed peat on the surface.

Humisol: a great group of soils in the Organic order that are saturated for most of the year. The soils have a dominantly humic middle tier, or middle and surface tiers if a terric, lithic, hydric, or cryic contact occurs in the middle tier.

Hummocky Moraine: a till landscape composed of distinct knobs and depressions.

Humus: that more or less stable fraction of the soil organic matter remaining after the major portion of added plant and animal residues have decomposed. Usually it is dark coloured.

Illuviation: the process of deposition of soil material removed from one horizon to another in the soil, usually from an upper to a lower horizon in the soil profile. Illuviated compounds include silicate clay, iron and aluminum hydrous oxides and organic matter.

Imbricate thrust sheets: a series of thrust sheets dipping in the same direction, sometimes called shingle-block structure.

Incised: cut down into, as a river cuts into a plateau

Inclined: a sloping, undirectional surface with a generally constant slope not broken by marked irregularities.

Insolation: the rate at which total solar energy (direct and sky radiation) is received on a surface.

Interfluve: the district between adjacent streams flowing in the same direction.

Interbedded: occurring between beds, or lying in a bed parallel to other beds of a different material; interstratified.

Kame:	an irregular ridge or hill of stratified glacial drift deposited by glacial meltwaters.
Keewatin:	district of the Northwest Territories from which a major ice sheet originated.
Key Wildlife Habitat:	habitat areas which are critical to a significant number of individuals of a species during at least part of the year. This may mean, for wild ungulates, wintering mean dancing grounds; for waterfowl it may mean production (nesting) and staging areas.
Lacustrine Deposit:	material deposited in lake water and later exposed either by lowering of the water level or by uplifting of the land. These sediments range in texture from sands to clays.
Land Classification:	the arrangement of land units into various categories based on the properties of the land or its suitability for some particular purpose.
Landforms:	the various shapes of the land surface resulting from a variety of actions such as deposition or sedimentation, erosion and earth crust movements.
Leaching:	the removal from the soils materials in solution.
Levee:	a natural or artificial embankment along a river or stream.
Lichen:	a symbiotic, mutalistic association of an algae and a fungus.
Litter:	uppermost layer (L layer) of organic debris on a forest floor, i.e. the freshly fallen or slightly decomposed material (mainly leaf material, but also bark, twigs, fruit).
Limestone:	bedded sedimentary deposit consisting chiefly of calcium carbonate ($CaCO_3$) which yields lime when burned.
Lithic Layer:	bedrock under the control section of a soil. In Organic soils, bedrock occurring within a depth of between 10 cm and 160 cm from the surface.
Lithology:	the physical character of a rock, generally as determined megascopically or with the aid of a low powered magnifier.

Loess:	material transported and deposited by wind and consisting of predominantly silt-sized particles.
Lowland:	the low lying land of a region, in contrast with the mountainous areas.
Luvisolic:	an order of soils that have alluvial (Ae) horizons, and illuvial (Bt) horizons in which silicate clay is the main accumulation product. The soils developed under forest or forest-grassland transition in a moderate to cool climate. The great group Gray Brown and Gray Luvisol belong to this group.
Macroclimate:	climate as viewed at the hemispheric scale, with only major waves, blocking actions and broad circulation features considered.
Massifa:	a mountainous mass or a group of connected heights, whether isolated or forming a part of a larger mountain system. A massif is more or less clearly marked off by valleys.
Matterhorn:	a sharp, hornlike or pyramid-shaped mountain peak.
Mean daily temperature:	a mean daily temperature is equal to the average of the daily maximum and minimum temperature. The mean monthly temperature is the average of each mean daily temperature for the month.
Meander:	one of a series of somewhat regular and loop-like bends in the course of a stream.
Mesa:	a tableland; a flat-topped mountain or other elevation bounded on at least one side by a steep cliff.
Mesic layer:	a layer of organic material at a stage of decomposition between that of the fibric and humic layers.
Mesisol:	a great group of soils in the Organic order that are saturated for most of the year. The soils have a dominantly mesic middle tier, or middle and surface tiers of a terric, lithic, hydric or cryic contact occurs in the middle tier.

Microclimate: the fine climatic structure of the air space that extends from the very surface of the earth to a height at which the effects of the immediate character of the underlying surface no longer can be distinguished from the general local climate (mesoclimate or macroclimate).

Mineral soil: a soil consisting predominantly of and having its properties determined predominantly by mineral matter. It contains less than 17% organic carbon except for an organic surface layer that may be up to 40 cm thick if formed of mixed peat (bulk density 0.1 or more) or 60 cm if of fibric moss peat (bulk density less than 0.1).

Morainal: sediment generally consisting of well compacted material that is non-stratified and contains a heterogeneous mixture of particle sizes, often in a mixture of sand, silt and clay that have been transported beneath, beside, on, within and in front of a glacier and not modified by an intermediate agent.

Mottles: spots or blotches of different color or shades of color interspersed with the dominant color.

Mudstone: an indurated clay rock which is not fissible.

Mull: a zoogeneous forest humus form consisting of an intimate mixture of well-humified organic matter and mineral soil that makes a gradual transition to the horizon underneath. It is distinguished by its crumb or granular structure, and because of the activity of the burrowing microfauna (mostly earthworms), partly decomposed organic debris does not accumulate as a distinct layer (F layer) as in mor and moder.

Muskeg: the term applied to alluvial areas with insufficient drainage, over which moss has accumulated to a considerable depth.

Organic: an order of soils that have developed dominantly from organic deposits. The majority of Organic soils are saturated for most of the year, unless artificially drained, but some of them are not usually saturated for more than a few days.

Orogency: the process of forming mountains, particularly by folding and thrusting.

Outwash:	sediments washed out by flowing water beyond the glacier and laid down as stratified drift in thin forest beds. The particle size may vary from boulders to silt.
Overstory:	the highest vertical relatively continuous layer of vegetative cover, e.g. the forest canopy in a forest system or a shrub canopy in a shrub system.
Parent material:	the unconsolidated and more or less chemically weathered mineral or organic matter from which the solum of a soil has developed by pedogenic processes.
Peat:	unconsolidated soil material consisting largely of undecomposed or only slightly decomposed organic matter.
Permafrost:	perenially frozen material underlying the solum.
pH, soil:	the negative logarithm of the hydrogen-ion activity of a soil. Most soil range in pH between 4.0-8.5.
Physiognomy:	the gross growth form of vegetation, e.g. grasslands, shrublands, forest.
Pitted:	a relatively flat area having prominent depressions or pits.
Porosity:	the volume percentage of the total bulk not occupied by solid particles.
Profile:	a vertical section of the soil throughout all its horizons and extending into the parent material.
Quartzite:	a granulose metamorphic rock consisting essentially of quartz.
Quaternary:	the latest period of time in the stratigraphic column, represented by local accumulations of glacial (Pleistocene) and post-glacial (Holocene) deposits which continue without change of fauna, from the top of the Pliocene (Tertiary).
Regosolic:	an order of soils having no horizon development or development of the A and B horizons insufficient to meet the requirements of the other orders. Regosol is the only great group in this order.

Relief: elevations or inequalities of a land surface, considered collectively. Land having no uneveness of differences of elevation is called level; gentle relief is called undulating; strong relief, rolling; and very strong relief, hilly.

Residual material: unconsolidated and partly weathered mineral materials formed by the disintegration of consolidated rock in place.

Ridged: a long, narrow elevation of the surface, usually sharp crested with steep sides. The ridges may be parallel, sub-parallel or intersecting.

Rolling: a very regular sequence of moderate slopes extending from rounded, sometimes confined concave depressions to broad, rounded convexities producing a wave-like pattern of moderate relief. Slope length is often 1.6 km or greater and gradients greater than 5%.

Sedimentary rock: a rock-formed from material deposited from suspension or precipitated from solution and usually more or less consolidated. The principal sedimentary rocks are sandstones, shales, limestones, and conglomerates.

Seral stage: a community stage or level of development in the sequence of vegetation succession.

Slumping: the downward slipping of a mass of rock or unconsolidated material of any size, moving as a unit or as several subsidiary units, usually with backward rotation on a more or less horizontal axis parallel to the cliff or slope from which it descends.

Soil drainage: the rate and ability of a soil to remove water in relation to the additions.

Steep: erosional slopes, greater than 35°, on both consolidated and unconsolidated material.

Stratum: a section of a formation that consists throughout of approximately the same kind of rock material.

Strike: the direction of a horizontal line along a rock stratum perpendicular to the direction of dip.

Structure, soil: the combination or arrangement of primary soil particles into secondary particles, units or peds. These peds may be, but usually are not, arranged in the profile in such a manner as to give a distinctive characteristic pattern. The

	peds are characterized and classified on the basis size, shape, and degree of distinctness into classes, types, and grades.
Succession:	the orderly replacement of one community stage by another over time.
Symmetrical fold:	a fold, the axial plane of which is essentially vertical, i.e. the two limbs dip at smaller angles.
Syncline:	a fold in rocks in which the strata dip inward from both sides toward the axis.
Talus:	a collection of fallen disintegrated material which has formed a slope at the foot of a steeper declivity.
Tarn:	a small mountain lake or pool, especially one that occupies an ice-gourged basin on the floor or a cirque.
Terrace:	(i) flat, gently inclined or horizontal surface bordered by an escarpment and composed of alluvium or bedrock; (ii) a relatively flat, elongate, stair-stepped surface bounded by a steep ascending slope on one side and a steep descending slope on the other. Terraces may be erosional or depositional; cut in rock (rock-cut) or unconsolidated soil materials (valleyfill cut); may be paired or unpaired on oppostive sides of a river; and may occur above an existing or former river, lake or ocean bed.
Thrust fault:	a reverse fault that is characterized by a low angle or inclination with reference to a horizontal plane.
Till:	unstratified glacial drift deposited directly by the ice and consisting of clay, sand, gravel and boulders intermingled in any proportion.
Understory:	the vegetation layer below the dominant canopy, usually trees.
Undulating:	a very regular sequence of gentle slopes that extend from rounded, sometimes confined concavities to a broad rounded convexities producing a wave-like pattern of low local relief. Slope length is generally less than 0.5 km and dominant gradient of slopes from 2% to 5%.
Upland:	the higher land of a region, in contrast with the valleys and plains.

Valley train: an outwash terrace extending down a valley away from the ice front.

Value, color: the relative lightnes of color, which is approximately a function of the square root of the total amount of light.

Veneer: unconsolidated materials too thin to mask the minor irregularities of the underlying unit surface. A veneer ranges from 10 cm to 1 metre in thickness.

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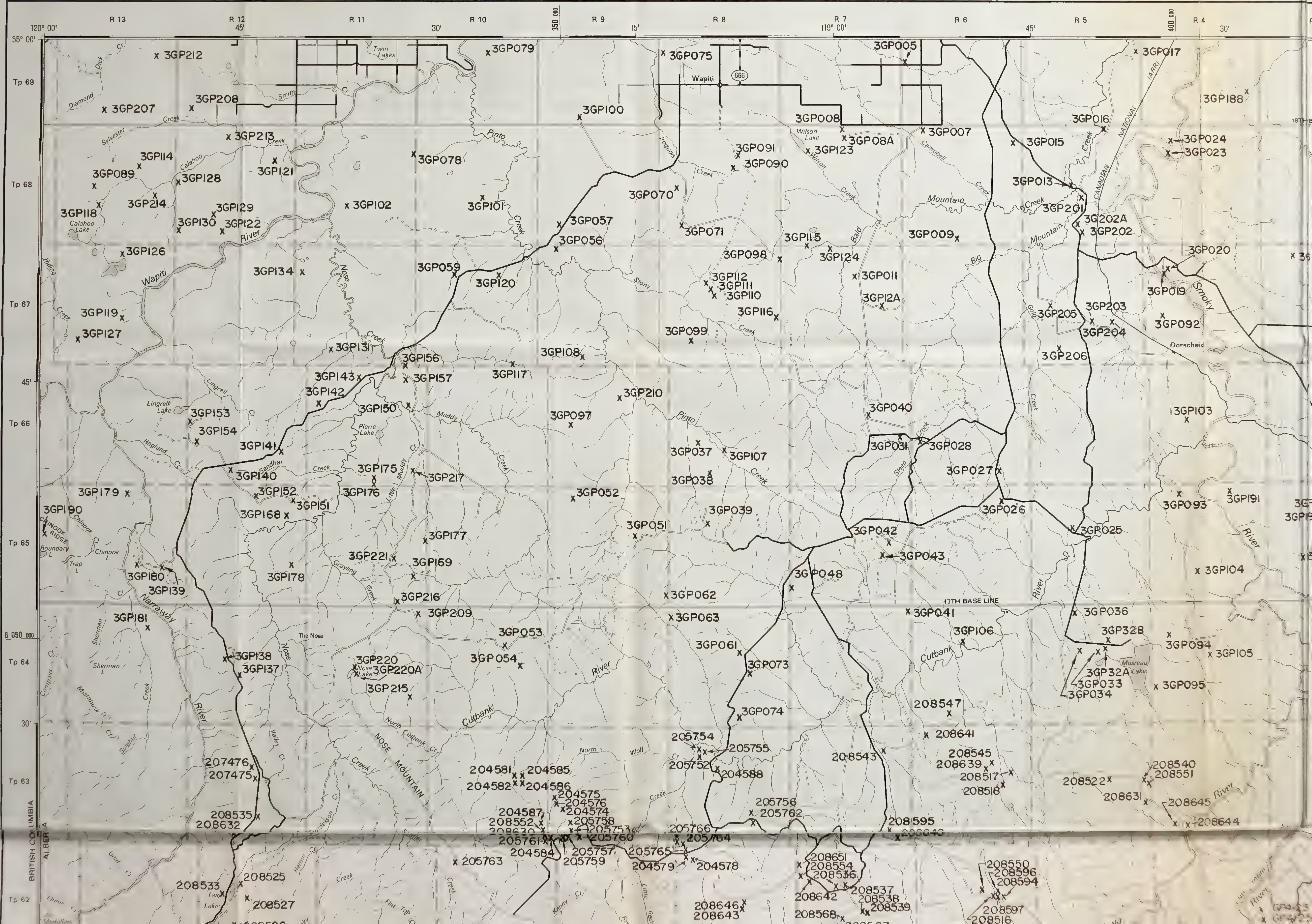

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Smoky River
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Pinto Creek
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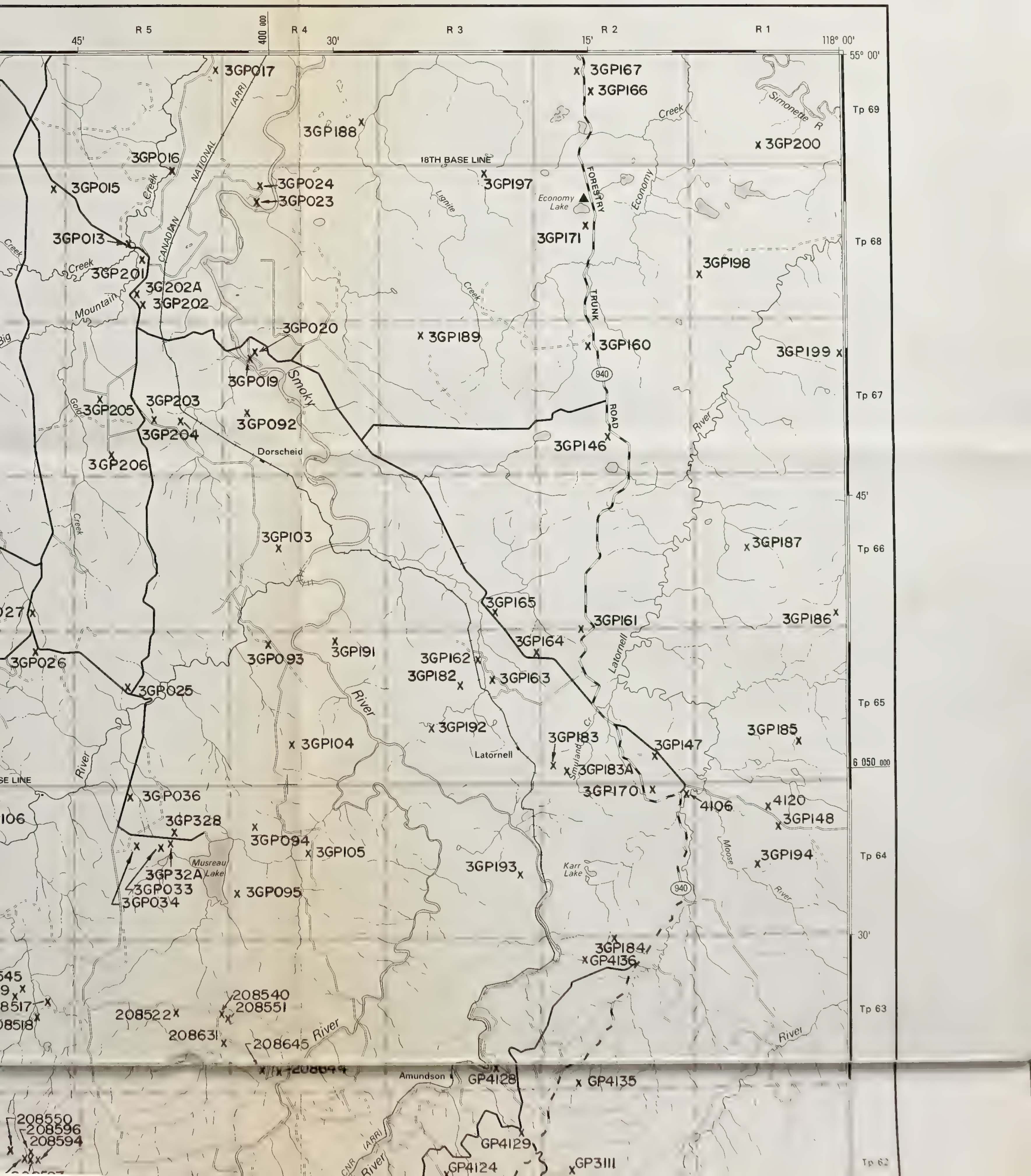

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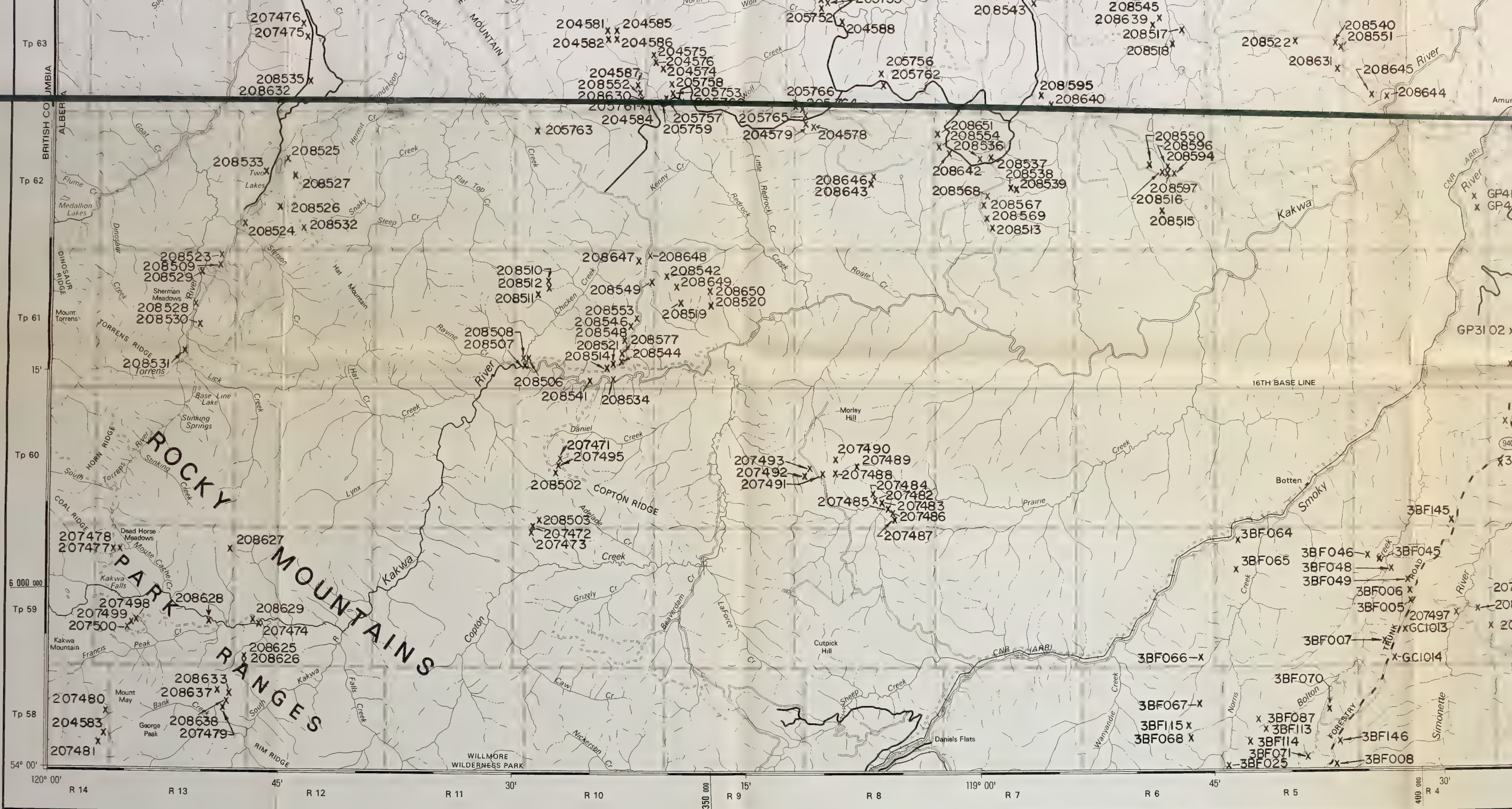

Alberta

ENERGY AND
NATURAL RESOURCES

SCALE 1 : 250 000

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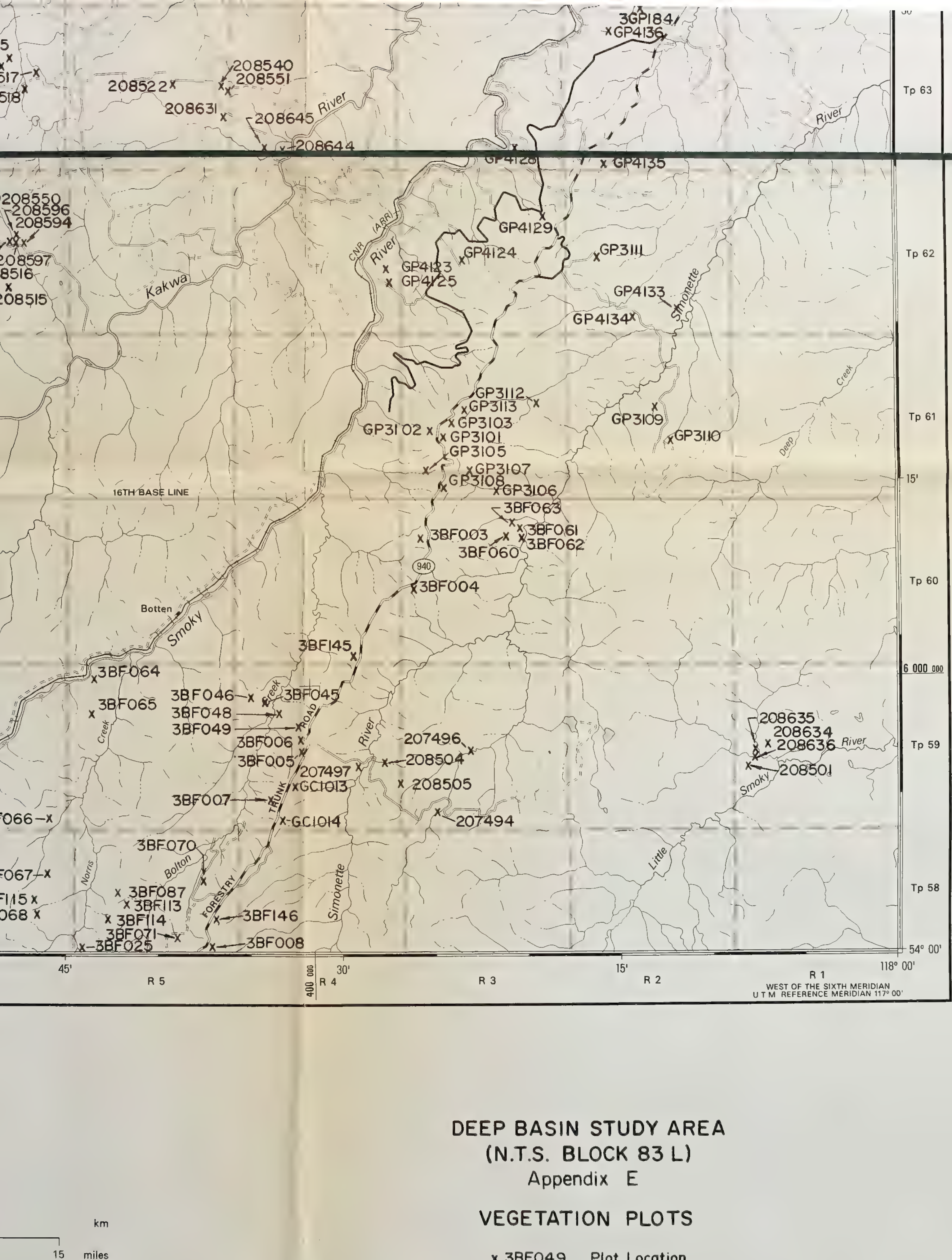
miles 5 0 5 10 15 miles

PRODUCED BY THE ALBERTA BUREAU



DEEP BASIN STUDY AREA
(N.T.S. BLOCK 83 L)
Appendix E

VEGETATION PLOTS

x 3BF049 Plot Location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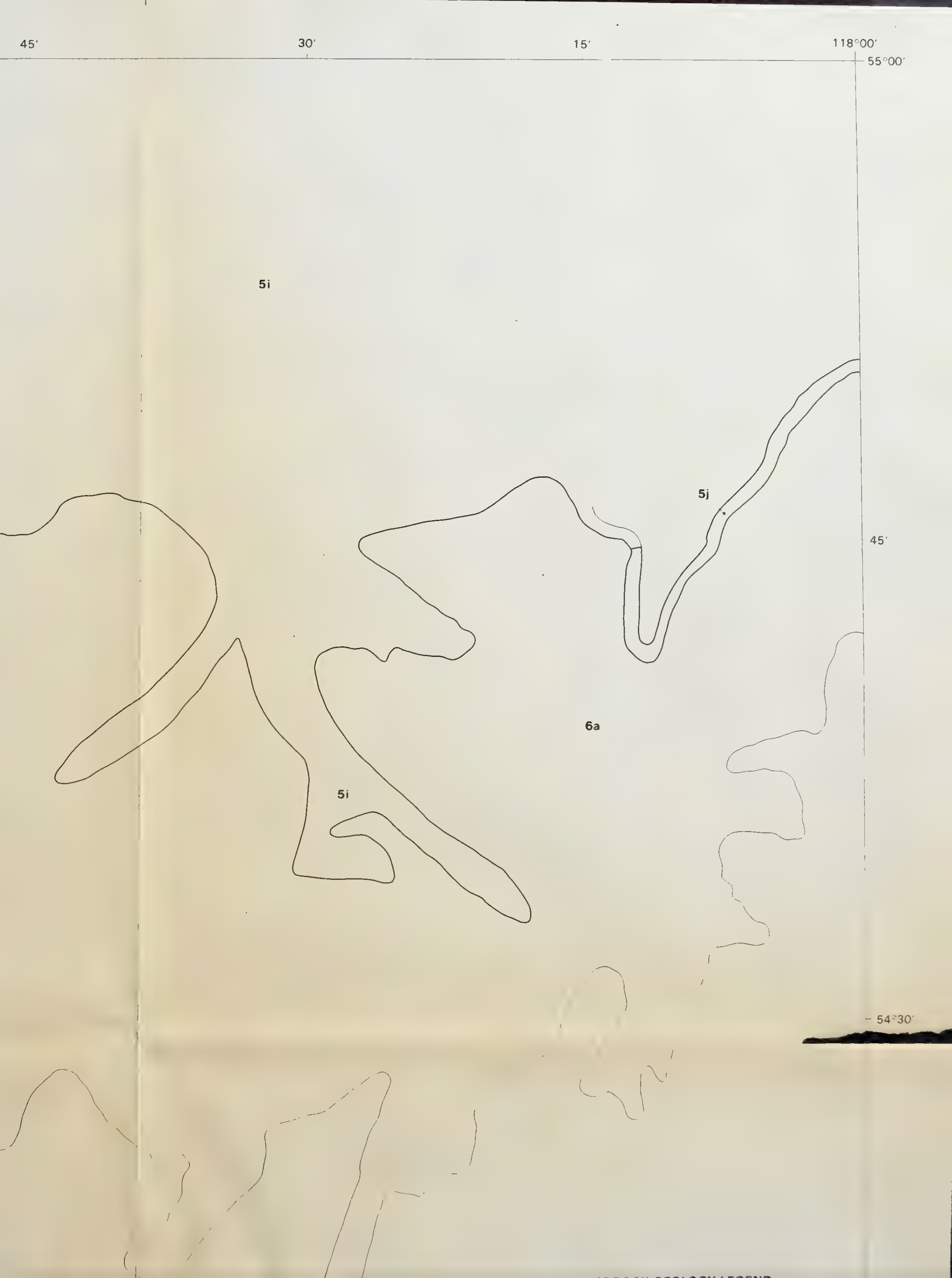
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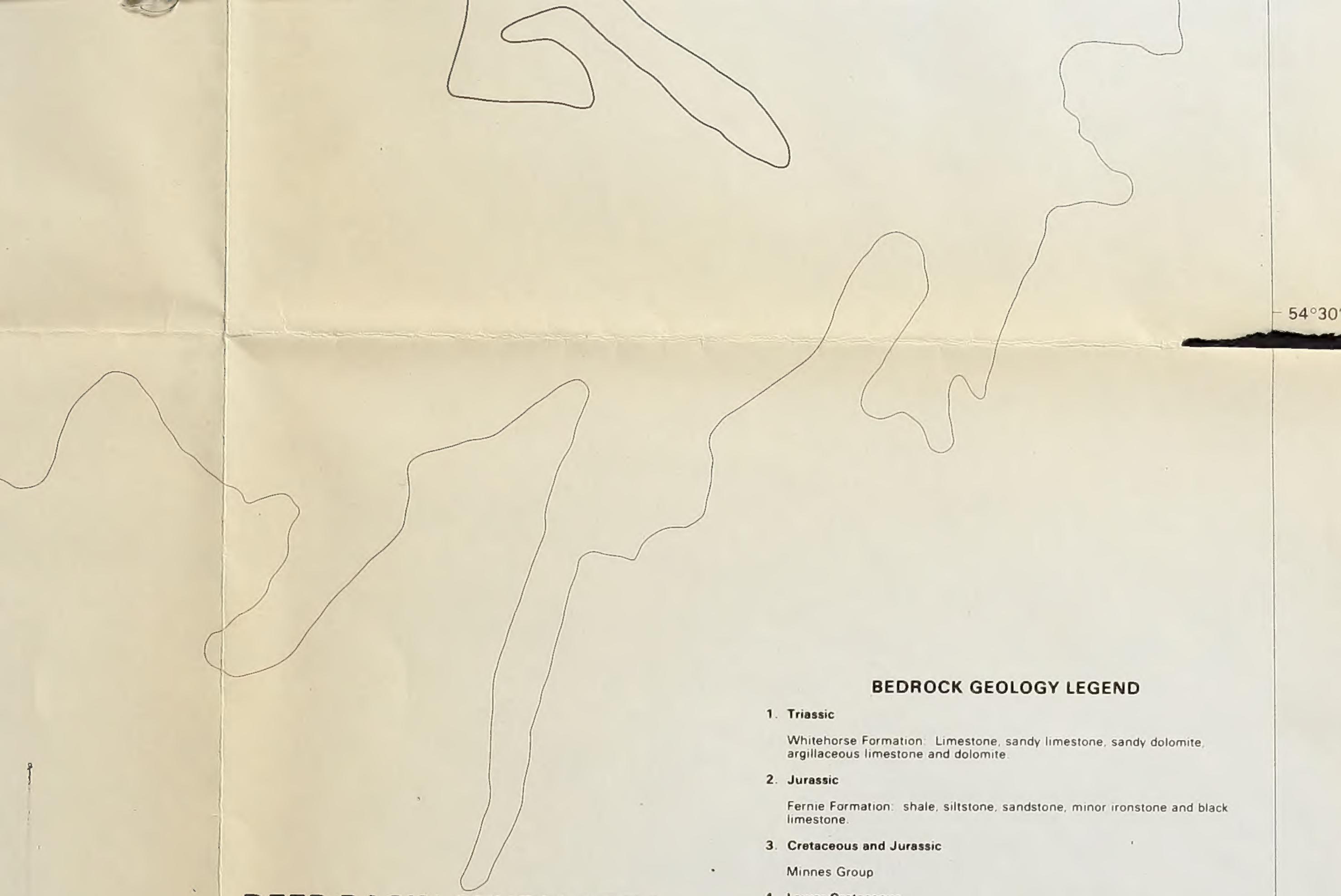
Figure 154: Bedrock Geology



DEEP BASIN STUDY AREA
(N.T.S. BLOCK 83 L)

SCALE 1 : 250 000

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mi. 2 0 2 4 mi.

West of the Sixth Meridian

LEGEND

GEOLOGICAL SYMBOLIZATION

defined

approximate

assumed

Fault

defined

approximate

BEDROCK GEOLOGY LEGEND

1. **Triassic**

   Whitehorse Formation: Limestone, sandy limestone, sandy dolomite, argillaceous limestone and dolomite.

2. **Jurassic**

   Fernie Formation: shale, siltstone, sandstone, minor ironstone and black limestone.

3. **Cretaceous and Jurassic**

   Minnes Group

4. **Lower Cretaceous**

   a) Cadomin Formation: conglomerate, minor sandstone

   b) Gething Formation: conglomerate, carbonaceous sandstone and shale, coal.

   c) Moosebar Formation: dark marine shale

   d) Blairmore Group

   e) Commotion Formation: (upper part) conglomerate, coarse to fine grained sandstone, shale, coal (middle part) dark marine shales, (lower part) carbonaceous sandstone, shale, coal.

   f) Shaftesbury Formation: fish scale bearing shale, interbeds of concretionary ironstone, bentonite partings

5. **Upper Cretaceous**

   a) Dunvegan Formation: sandstones with calcareous beds, laminated siltstone, sandy shale.

   b) Kaskapau Formation: dark marine silty shale, innerbeds of ironstone, sandstone, mudstone.

   c) Cardium Formation: fine grained sandstone, shale

   d) Muskiki Formation: sandstone, mudstone, conglomerate, shale

   e) Badheart Formation: fine grained marine sandstone, mudstone.

   f) Puskwaskau Formation: fossilferious shale, (Hanson, Thistle and Dowling members).

   g) Puskwaskau Formation: fossiliferious shale (Chungo and Hanson members).

   h) Puskwaskau Formation (undivided): fossiliferious shale

   i) Wapiti Formation: Clayey sandstone, bentonitic mudstone, bentonite

   j) Whitemud and Battle Formations: pale grey, bentonitic sandstone and mudstones (Whitemud formation).

   k) Brazeau Formation: grey, fine-grained, feldspathic sandstone with hard calcareous beds; laminated siltstone and grey silty shale; deltaic to marine.

6. **Tertiary and Cretaceous**

   a) Scollard Member (Paskapoo Formation): sandstone, shale and major coal seams (including Ardley "coal zone"); non-marine.

   b) Paskapoo Formation: sandstone, siltstone, shale and thin coal seams.

Source: Surveys and Mapping Branch,
Department of Mines And Technical Surveys,
Ottawa